REPORT RESUMES

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COMBINES AND COMBINING.

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DESCRIPTORS- *STUDY GUIDES, *AGRICULTURAL MACHINERY, *VOCATIONAL AGRICULTURE, HIGH SCHOOLS,

THROUGH THE USE OF THIS MANUAL, VOCATIONAL AGRICULTURE STUDENTS WITH OCCUPATIONAL INTEREST IN GRAIN FARMING AND CUSTOM COMBINE OPERATION MAY GAIN KNOWLEDGE ABOUT THE BASIC DESIGN AND OPERATION OF COMBINES. DEVELOPMENT BY A STATE CURRICULUM MATERIALS DIRECTOR INCLUDED CONSULTATION WITH ENGINEERS, TRIAL, AND REVISION. OBJECTIVES ARE STATED IN TERMS OF BEHAVIORAL OBJECTIVES AND BASED ON STUDENT NEEDS. FOUR UNITS OF INSTRUCTION ARE COVERED -- (1) WHAT IS THE VALUE OF DOING A GOOD JOB OF COMBINING, (2) BASIC DESIGN OF THE COMBINE, (3) OPERATION OF THE COMBINE, AND (4) ECONOMICS OF OWNING A COMBINE. THE MANUAL SUGGESTS TEACHING PROCEDURES AND STUDENT EXPERIENCES WHICH THE VOCATIONAL AGRICULTURE TEACHERS COULD CONDUCT IN THE CLASSROOM, THE AGRICULTURAL MECHANIC SHOP, AND ON FIELD TRIPS TO FARMS AND IMPLEMENT DEALERS. SINCE THE INDIVIDUAL FEATURES OF THE DIFFERENT MAKES AND MODELS OF COMBINES CANNOT BE INCLUDED IN ONE PUBLICATION, OPERATOR'S MANUALS FOR THE COMBINES BEING STUDIED SHOULD BE MADE AVAILABLE. A SET OF THIRTY 2- BY 2-INCH COLOR SLIDES WITH ACCOMPANYING SCRIPT, AND A TEST AND KEY FOR THE UNIT ARE AVAILABLE. THIS DOCUMENT IS AVAILABLE FOR $1.00 OR IN QUANTITY FOR 75 CENTS FROM OHIO VOCATIONAL AGRICULTURE, INSTRUCTIONAL MATERIALS SERVICE, THE OHIO STATE UNIVERSITY, 2120 FYFFE ROAD, COLUMBUS, OHIO 43210. (FA)

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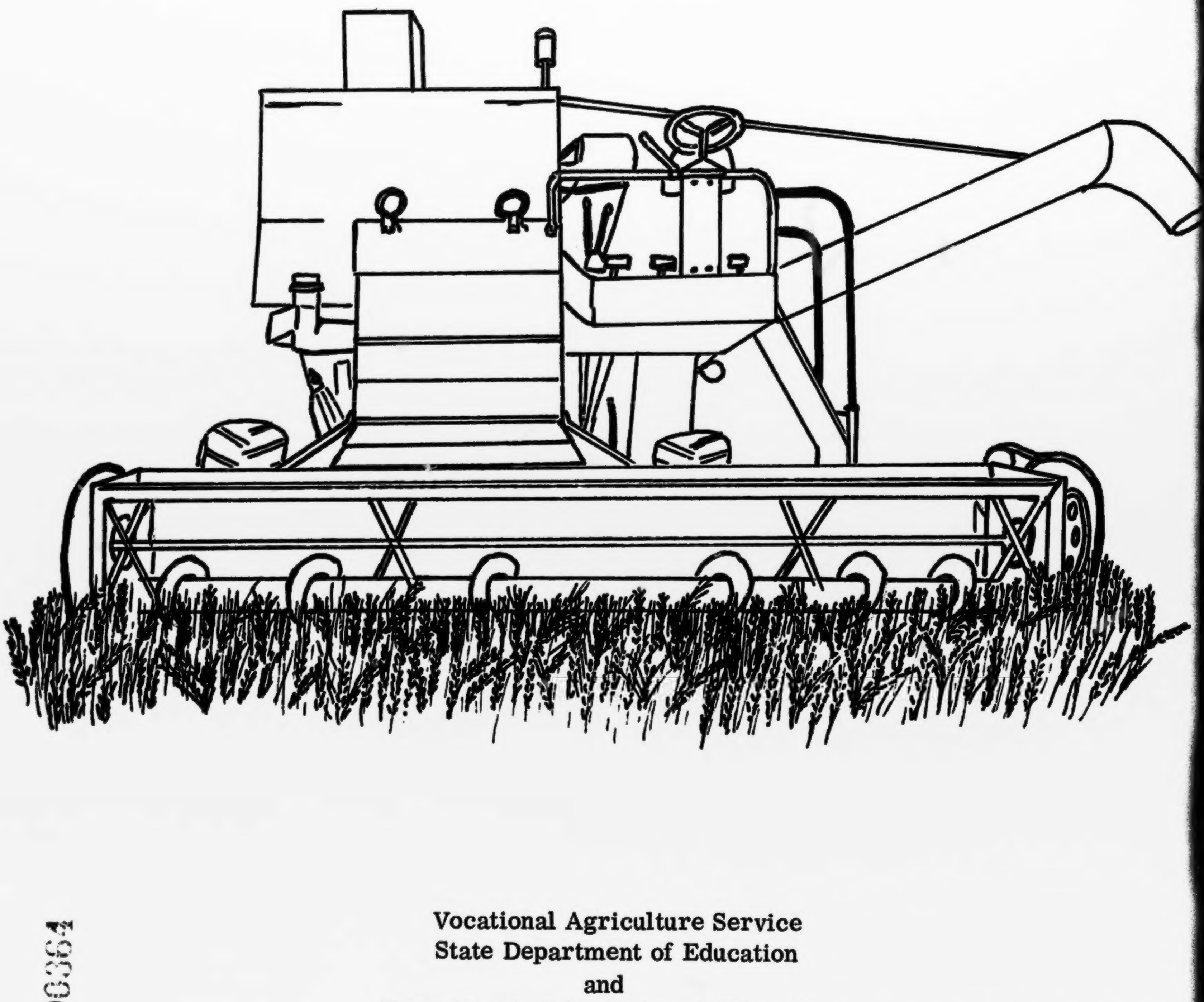
COMBINES AND COMBINING



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and
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1965

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APPLICATION OF THE UNIT

COMBINES AND COMBINING

The manual "Combines and Combining" has been developed by the Ohio Vocational Agriculture Instructional Materials Service to assist vocational agriculture students in gaining knowledge about this important harvesting machine. For most efficient use, each student should have a copy of the manual available during his study of the unit on combines. The manual suggests teaching procedures and student experiences that would be conducted in the classroom, the agricultural mechanics shop, and on field trips to farms and implement dealers.

The manual is not designed to be used as a workbook, although there are certain forms designed for recording information during the course of study that the teacher may wish to reproduce in quantities for student use. This may be accomplished by preparing spirit masters with an office copying machine for reproduction with a duplicating machine. The same office copying machine will usually prepare transparencies for use with the overhead projector.

For most effective work the students should have ready access to a combine to enable them to put their theory into practice. It is highly recommended that one or more combines be available in the agricultural mechanics shop during the course of study. Other combines may be studied during field trips to farms and to implement dealers.

Since the individual features of the different makes and models of combines cannot be included in one publication, it is also strongly recommended that the operator's manual for the combines being studied be made available. This manual refers to the manufactures operator's manual for specific recommendations and adjustments. If the operator's manual is not available locally, copies may be obtained from the manufacture's branch office.

SUPPLEMENTAL MATERIALS

A set of thirty 2 x 2" color slides has been selected from several hundred slides made available by Allis-Chalmers, J. I. Case, and The International Harvester Companies to illustrate the operation and design of the combine. The slides, with the accompanying script,may be purchased from the Vocational Agriculture Instructional Materials Service.

A sample 50-question examination and key has been prepared in accordance with the educational objectives that were followed in developing the manual. The examination contains the following type questions: true or false, multiple choice, matching, and mathematical problems. In addition to the 50 questions, the illustrations showing the combine cross section and the flow chart found on pages 22 and 24 respectively are included as part of the examination. Copies of the examination may be purchased from the Vo-Ag Instructional Materials Service.

EDUCATIONAL OBJECTIVES

Effective teaching has resulted when an evaluation indicates that students have attained desirable knowledge, skills, attitudes, and asperations in the subject being taught. The ability to think clearly in the subject matter area as well as the ability to perform manual operations is an important goal.

The following objectives, stated in terms of student needs and behavior, were used as a guide in developing the manual:

STUDENT NEEDS —

1. To appreciate the harvesting losses that may occur when the combine is improperly operated and adjusted.
2. To appreciate the economic loss that can occur.
   a. Through grain lost in the field.
   b. By marketing a damaged and contaminated product.
3. To understand the design and principles of operation of the combine.
4. To understand the principles of the various combine adjustments.
5. To be able to evaluate his need for a combine.
6. To be able to select a combine that will meet his needs.
7. To be able to understand practical and experimental knowledge concerning combine operation and desing.

DESIRED STUDENT BEHAVIOR —

1. The ability to recognize and determine the extent of combine harvesting losses.
   a. Field losses.
   b. Machine losses.
   c. Damaged grain loss.
   d. Losses due to foreign material in the grain.
2. To identify the basic operations of the combine.
   a. Cutting and feeding.
   b. Threshing.
   c. Separation.
   d. Cleaning.
3. To identify the cause of each kind of combine loss.
4. To make proper adjustments with the machine or method of operation to correct the losses.
5. To determine his need for a combine in his farming operation.
6. To select a combine that will meet his farming needs.
7. To make repairs on his combine.
8. To apply practical and experimental knowledge in solving combining problems.
9. To make use of the manufactures operator's manual in operating and repairing the machine.

ACKNOWLEDGEMENTS

The manual "Combines and Combining" was prepared by Harlan E. Ridenour of the Ohio Vocational Agriculture Instructional Materials Service. Many persons provided invaluable assistance in compiling and organizing the material presented in this manual. The manuscript has been reviewed by Mr. S. G. Huber, Department of Agricultural Engineering, Dr. G. S. Guiler, Department of Agricultural Education, The Ohio State University, and Dr. W. H. Johnson, the Ohio Agricultural Experiment Station, for both content and arrangement. Dr. Ralph J. Woodin of the Department of Agricultural Education provided assistance in determining the organization of the manual.

Farm machinery company representatives from the following Columbus, Ohio branch offices provided assistance and materials for the manual: Allis-Chalmers Manufacturing Company, J. I. Case Company, International Harvester Company, John Deere Company, and Massey-Ferguson Company.

The first printing of the manual "Combines and Combining" has been extensively reviewed by D. M. Byg, Extension Agricultural Engineer, Farm Machinery, of The Ohio State University. Mr. Byg has suggested certain changes and additions which have been included in the second printing. In addition, D. M. Byg, W. E. Gill and W. H. Johnson conducted a survey to determine the actual grain losses that farmers were experiencing with their corn harvesting equipment throughout the 1964 harvest season. Some of the findings resulting from this survey have been added to the manual.

Harlan E. Ridenour
Ohio Vocational Agriculture
Instructional Materials Service

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COMBINES AND COMBINING

I. WHAT IS THE VALUE OF DOING A GOOD JOB OF COMBINING?

The combine can be adapted to harvest any of our seed growing crops by use of the appropriate attachments and by making the proper adjustments on the machine for the kind of crop to be harvested. The principles of operation are the same for each of the crops even though different attachments may be used. In Ohio the combine is widely used in the harvesting of our grain crops. This means that we must understand how to operate the combine properly if we are to avoid large losses of grain at harves time.

The large investment the farmer has in grain crops makes it important to harvest all the high quality grain he can from his fields. A recent study shows that the cost per acre of raising the following crops was: corn - $58.85, soybeans-$44.25, and wheat - $47.30.[1]

Student exercise: Study your farming program or farm account records to find your cost of production per acre for the crops you will be harvesting with the combine. Does this make it seem important to save all the high quality grain you can?

A. WHAT KIND OF LOSSES DO WE HAVE BECAUSE OF POOR COMBINE OPERATION AND ADJUSTMENT?

1. Field losses of grain.

No matter how careful we are some grain will always be left in the field. Some will be lost on the ground before combining, some will be missed by the machine because of cutting too high or poor driving, while some will be lost through the machine because the heads are not completely threshed out or the kernels thrown out of the machine. These losses will be greater than necessary unless the combine is properly operated and adjusted.

The graph shown in Figure 1 may be used to show the dollars per acre loss with different possible rates of loss per acre with grain at different prices.

2. Marketing losses caused by poor quality grain.

Poor adjustment and operation of the combine may cause damaged grain that will lower the sale price or storage quality. This will cause an economic loss to the farmer. By understanding the principles of operation of the combine these losses can be kept to a minimum.

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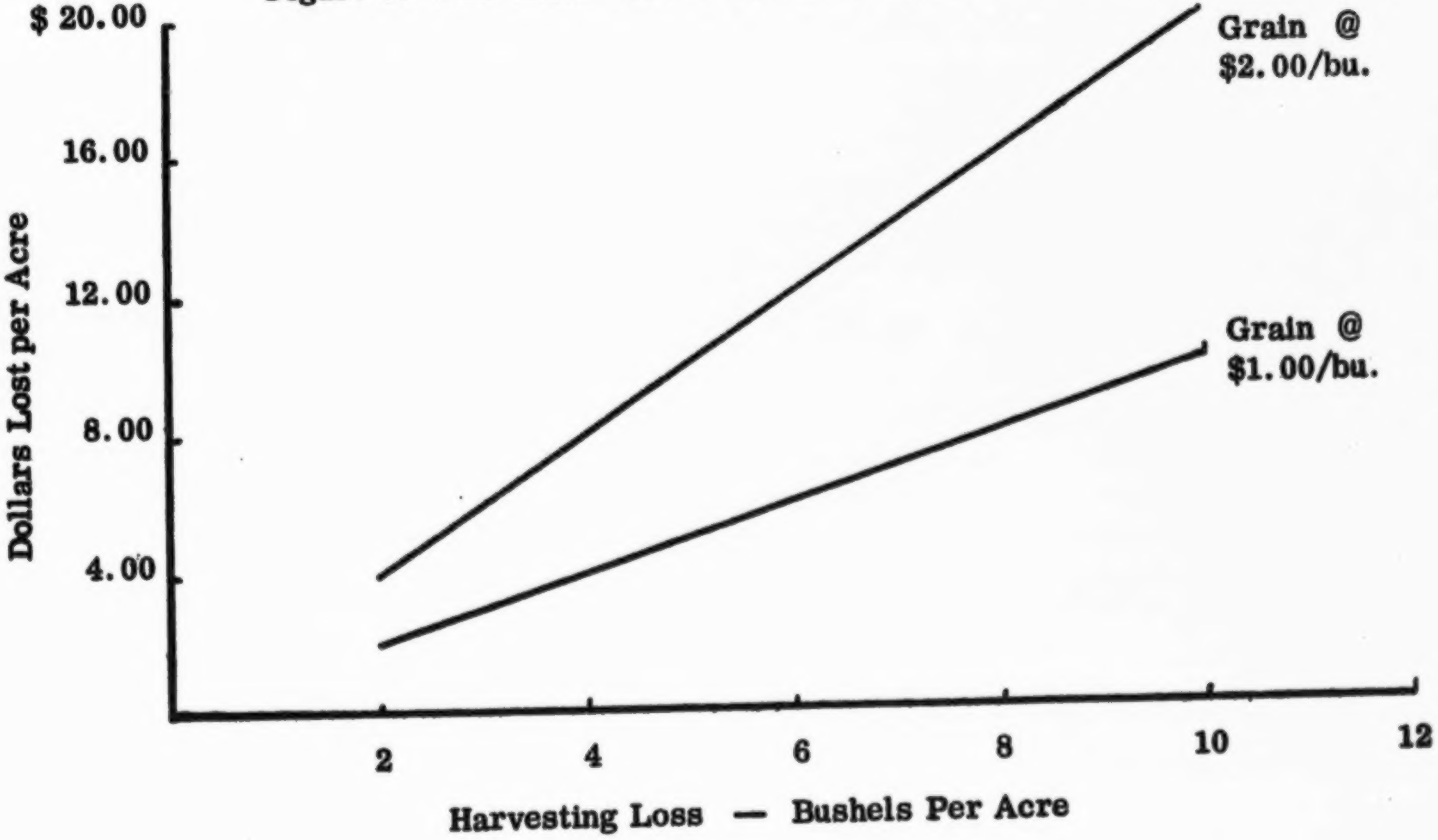
[1] G. V. Vollmar and R. H. Blosser, Crop Economics for Ohio, Bulletin 423, The Ohio State University, Department of Agricultural Economics.

Grain damage that will cause the price to be discounted include the following: low test weight per bushel, high moisture content, heat damage, foreign material, shrunken-broken kernels, and split grain in the case of soybeans. These losses can be kept to a minimum by proper timing of the combine operation and by having the machine in proper adjustment.

Figures 2, 3, and 4 prepared by Ross Milner, Extension Specialist, Grain Marketing, The Ohio State University, show the effect of the different kinds of grain damage and the approximate discounts that may be applied to the market price of the grain.

Figure 1. How much does it cost to do a poor job of combining?



In the example above the loss in dollars per acre has been plotted for grain prices at $1.00 and $2.00 per bushel for losses from 2 to 10 bushels per acre. You may substitute any crop at its current market value and plot the dollar loss for different harvesting losses.

FIGURE 2

SOFT RED WINTER AND WHITE WHEAT GRADES - PREMIUMS AND DISCOUNTS*

Grade Factors	Grade No. 2	Approximate Discounts by Processors and Terminals
Test Weight	Min. 58 lbs.	(1/2¢ each 1/2 lb. under 58 thru 56 lbs.) (1 ¢ each 1/2 lb. under 56 thru 54 lbs.) (1 1/2 ¢ each 1/2 lb. under 54)
Total Damage	Max. 4%	1¢ each 1% or fraction 4.1% thru 10%
Heat Damage	Max. 0.2%	negotiated in excess of 0.2%
Foreign Material	Max. 1%	1¢ each 1% or fraction 1.1% thru 5%
Shrunken & Broken	Max. 5%	negotiated in excess of 5%
Total Defects	Max. 5%	negotiated in excess of 5%
Wheat of Other Classes	Max. 5%	SRW with white 1/2¢ 5.1% thru 10%
Additional Grade Factors (always SAMPLE GRADE when present)		
Inseparable Stones (7 or more)		negotiated
Musty or sour odors		10¢ per bushel
C.O.F.O. 1/		negotiated
Heating		negotiated
D.L.Q. 2/		negotiated or rejected

Special Grade, TOUGH, over 13 1/2% moisture. (14%, -1¢) (14.5%, -3¢) (15.0%, -5¢) (15.5%, -8¢) or dry and shrink.

FIGURE 3

CORN GRADES - PREMIUMS AND DISCOUNTS*

Grade Factors		Buying Grade No. 2	Approximate Discounts by Processors and Terminals
Test Weight	Min.	54 lbs.	1/2 to 1¢ each lb. or fraction under 54 lbs.
Moisture	Max.	15.5%	1 to 1/2¢ each 1/2% over 15 1/2%
Broken & F.M.	Max.	3 %	1¢ each 1% or fraction over 3%
Total Damage	Max.	5 %	1/2 to 1¢ each 1% or fraction over 5%
Heat Damaged	Max.	0.2%	1/2¢ each 1/10% over 2/10% to 3% then 1¢ each 1/10%
Additional Grade Factors (Always SAMPLE GRADE when present)			
Inseparable Stones (over 7)			Subject to negotiation
Musty			5 to 10¢ or subject to negotiation
Sour			10¢ or subject to negotiation
Heating			5 to 10¢ or subject to negotiation
C.O.F.O. 1/			subject to negotiation
D.L.Q. 3/			subject to negotiation or rejection

FIGURE 4

SOYBEAN GRADES - PREMIUMS AND DISCOUNTS *

Grade Factors		Buying Grade No. 1	Buying Grade No. 2	Approximate Discounts by Processors and Terminals
Test Weight	Min. lbs.		54	1/2 cent each lb. or fraction under 54
Moisture	Max. %	13		2 to 2 1/2¢ each 1/2% or fraction over 13%
Splits	Max. %		20	1/4¢ to each 5% or fraction over 20%
Total Damage	Max. %	2		1¢ each 1% or fraction over 2%
Heat Damaged	Max. %		.5	1¢ each .5% or fraction over .5%
Foreign Material	Max. %	1		All over 1% deducted from weight
Other Colors 4/	Max. %	1		1/2¢ each 1% or fraction over 1%
Musty		Sample		negotiated
Sour		Sample		negotiated
Heating		Sample		negotiated
C. O. F. O. 1/		Sample		negotiated
Inseparable Stones (over 7)		Sample		negotiated
D. L. Q. 5/		Sample		negotiated
Purple Mottled or Stained 6/		Not higher than No. 3		negotiated
Materially Weathered		Not higher than No.4		negotiated

1/ C.O.F.O. - Commercially objectionable foreign odors -- includes skunk, smoke, burned decaying plants or animals, oil, etc.

2/ D.L.Q. Wheat - Distinctly low quality -- included three or more rat and mouse pellets, bird droppings, and treated pink wheat. Also large stones, glass, caster beans, Crotolaria seeds, foreign substances and other unusual conditions.

3/ D.L.Q. Corn - Distinctly low quality -- includes rodent excreta in excess of .2% based on 1 1/8 to 1 1/4 quarts of original sample, stones, pieces of glass and concrete too large to enter the probe, castor beans, cockleburs, Crotalaria more than 2 in 1000 grams and unknown foreign substances or commonly recognized harmful or toxic foreign substances. Also, other unusual conditions which adversely affect the quality and which cannot be properly graded by specified factors.

4/ Other Colors - mean brown, black and/or bi-colored soybeans in yellow or green soybeans. Color is a grading factor up to and including 10% of other colors. Above 10% class changes to "Mixed Soybeans."

5/ D.L.Q. Soybeans - Distinctly low quality -- large stones, glass, concrete too large to enter the probe, castor beans, more than 2 Crotalaria seeds/1000 grams, visible contamination by rodents, birds or other sources of filth, unknown foreign substance or a commonly recognized harmful or toxic foreign substance, and other unusual conditions which adversely affect the quality.

6/ Includes discoloration due to fungus growth, dirt or nontoxic inoculants and other nontoxic substances.

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* Ross Milner, Extension Specialist, Grain Marketing, The Ohio State University.

3. Operating the combine with improper adjustments or under poor conditions may require excessive amounts of power. This will increase the cost of harvesting the crop.

4. Operating the combine under poor conditions with improper adjustments will increase the wear on the machine. This will shorten the life of the combine and increase repair bills.

B. CHARACTERISTICS OF A GOOD JOB OF COMBINING.

A poor job of combining means that too much grain will be left in the field and that some will be damaged so much that the market grade will be lowered. Both of these losses mean that we will not receive as much for our work and investment as we would if we did a good job of combining. The cost of doing a good job is no more than for doing a poor job.

Let us see if we can tell what a good job of combining should be like. Where would you look?

The field.

1. Uncut grain left standing.
2. A few grains left in some of the heads.
3. Straw and heads are not excessively chewed up.

The machine.

1. Very few unthreshed heads at the rear of the machine.
2. Material spread evenly over the rack.
3. Little or no grain found coming from shoe or rack.
4. A small amount of material in the tailings auger.

The grain tank.

1. The grain is not cracked.
2. There is a small amount of chaff and other foreign matter in the grain.
3. The grain has a satisfactory moisture content for storage or marketing without excessive losses.

C. WHAT ARE THE THINGS THAT EFFECT THE KIND OF JOB OF COMBINING WE SHOULD DO?

1. The combine:
    a. The power needed to run the combine at constant r.p.m. (revolutions per minute.).
    b. The speed of forward travel.
    c. The adjustment of the combine.
    d. The skill of the operator.
    e. The width of the combine.

2. The natural conditions.

    a. The lay of the land. (Topography.)
    b. The condition of the crop for threshing.
    c. The stand of the crop.
    d. The amount of weeds in the field.
    e. The variety of the crop.

D. THERE ARE SEVERAL THINGS WE NEED TO KNOW ABOUT A COMBINE IF WE ARE TO BECOME EFFICIENT OPERATORS WITH THE ABILITY TO DO THE KIND OF JOB WE DESCRIBED.

Even if we hire our combining done we should be able to tell whether or not the custom operator is doing a good job for us.

Some of the things we need to know are listed here. They will be studied in more detail later in this manual.

1. To understand the functional design of the combine.
2. To understand the basic principles of operation of the combine.
3. To have the ability to identify combine losses.
4. To have the ability to make the proper adjustments on the combine to keep the losses as low as possible.
5. To have the ability to maintain the combine in efficient operating condition.
6. To have the ability to determine the need for a combine in the farming operation and to select the machine that would best meet the need.

II. THE BASIC DESIGN OF THE COMBINE:

In studying the design of the combine it is recommended that one or more combines be available in the school shop. These may be obtained from the students' home farms or from a local implement dealer. Copies of the operator's manual should also be provided for the combines being studied. Quantities for class use can usually be obtained by writing direct to the manufacturer. The use of the operator's manual will serve two purposes: (1) to help in identifying the parts of the combine, their function and necessary adjustments, and (2) to illustrate the importance of using the operator's manual when working with the combine.

A. TYPES OF COMBINES.

1. Width of cut is one way of classifying combines.
2. The way power is supplied is another classification.
    a. Pull type power take-off drive.
    b. Pull type with an auxilliary engine to supply cutting and threshing power.
    c. Self-propelled combines.

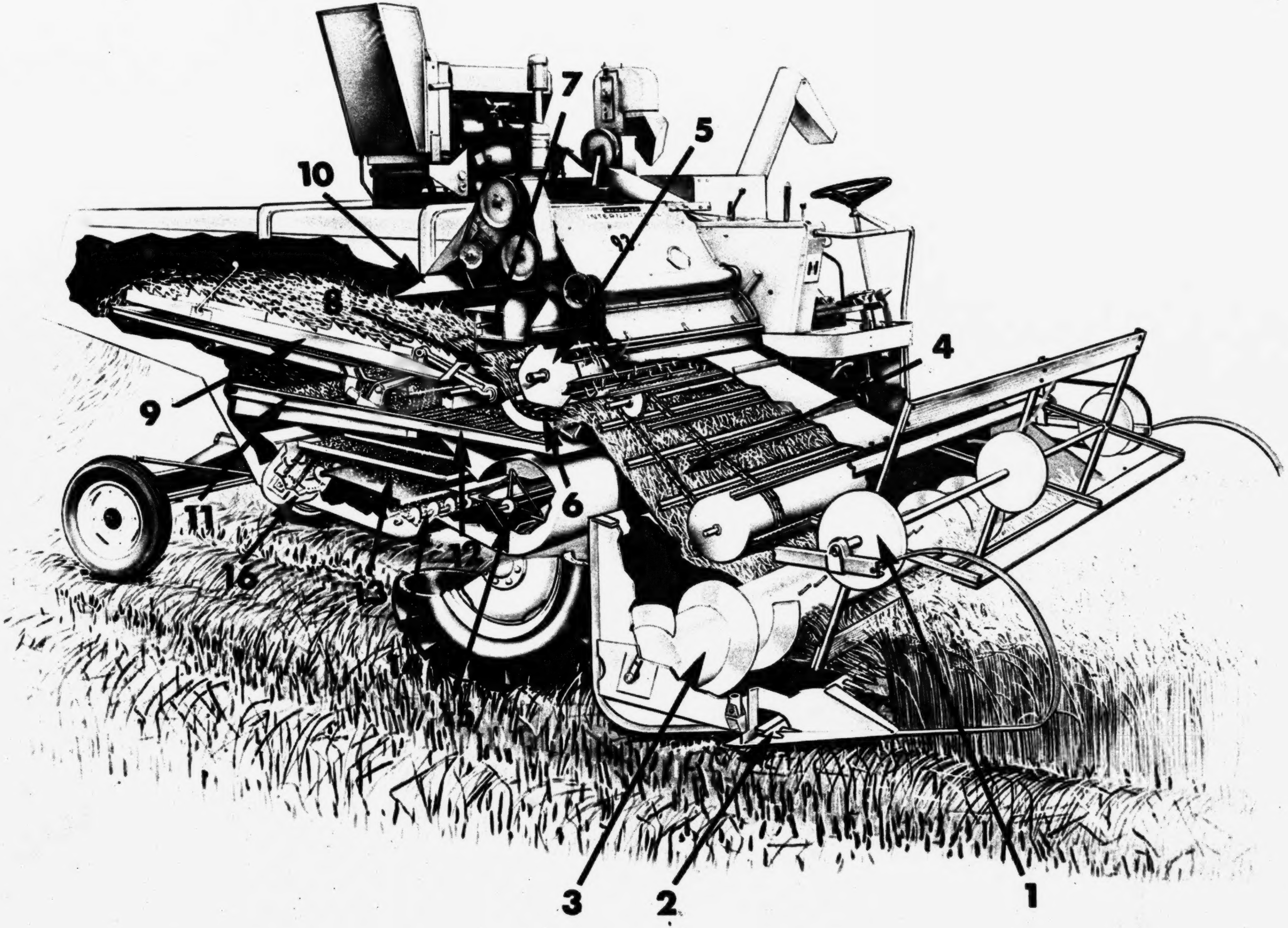
B. BASIC OPERATIONS PERFORMED BY THE COMBINE.

As the name implies the combine harvester performs several harvesting operations at the same time. The grain is cut, or picked in the case of corn, fed into a threshing unit where the grain is removed from the husk, the grain is then separated from the straw or husks, and finally the grain is cleaned and delivered into the grain tank.

A study of the cross section of the combine will help in understanding what takes place in the machine when it is operating and also will show the relationship of one part of the combine to another. (See figure 5.) To do a good job of combining the operator must understand the function of each unit of the combine, its adjustment, and the effect of each adjustment on the performance of the machine.

1. Cutting and feeding unit: Figures 6, 7, and 8.

The function of this section of the combine is to cut only as much of the crop as is necessary to get all the heads, lay the cut crop on the platform or auger, and then feed it uniformly into the threshing unit. Different makes and models of the combines will do this in somewhat different ways.


10
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16
13
12
15
3
2
1

Figure 5. Combine Operating Cycle. Courtesy International Harvester Company.

The Combine Operating Cycle (Figure 5)

The reel (1) momentarily holds the crop against the guards until the knife (2) cuts the stems, and then it sweeps the cut material onto the platform. The platform auger (3) delivers the cut grain to the feeder (4) which carries the cut grain to the cylinder (5). The grain is rubbed out of the head between the rotating cylinder (5) and the concave grates (6). The cylinder beater (7) strips the cylinder, continues separating loose kernels of grain through the finger grate (8) then moves the material onto the straw rack (9) where final separation takes place. The adjustable cylinder beater check flap (10) regulates the flow of material over the racks. The grain pan (12) catches the grain separated at the concave, cylinder beater grate, and return from the straw racks and delivers it to the chaffer (11). The cleaning fan (15) supplies the wind blast which is the medium of separation. The shoe and sieve (13) operates in the direct oppostie tothe grain pan and chaffer which assures double action cleaning (as the grain pan and chaffer moves forward, the shoe and shoe sieve move towards the rear.) The shoe sieve (13) is where the final cleaning takes place. The threshed grain falls through the chaffer, and shoe sieve, and into the grain trough (14) where it is moved to the grain elevator by the grain auger. The grain elevator conveyor chain then delivers the clean grain to the grain tank. Unthreshed heads will move rearward across the chaffer and shoe sieve and drop into the tailings return auger trough (16). From this point, the unthreshed heads are returned by the tailings elevator to the cylinder for re-threshing.

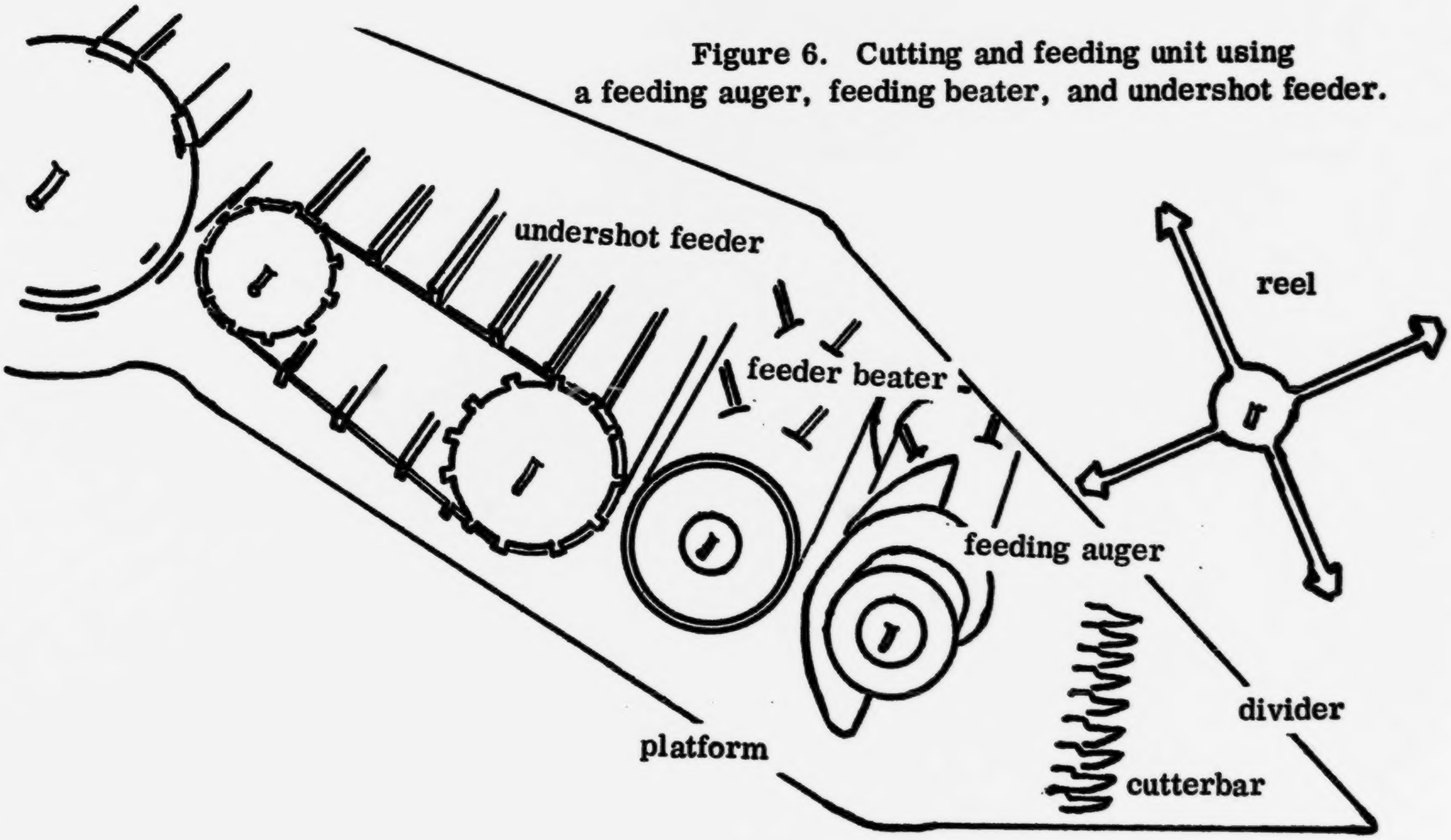


Figure 6. Cutting and feeding unit using a feeding auger, feeding beater, and undershot feeder.

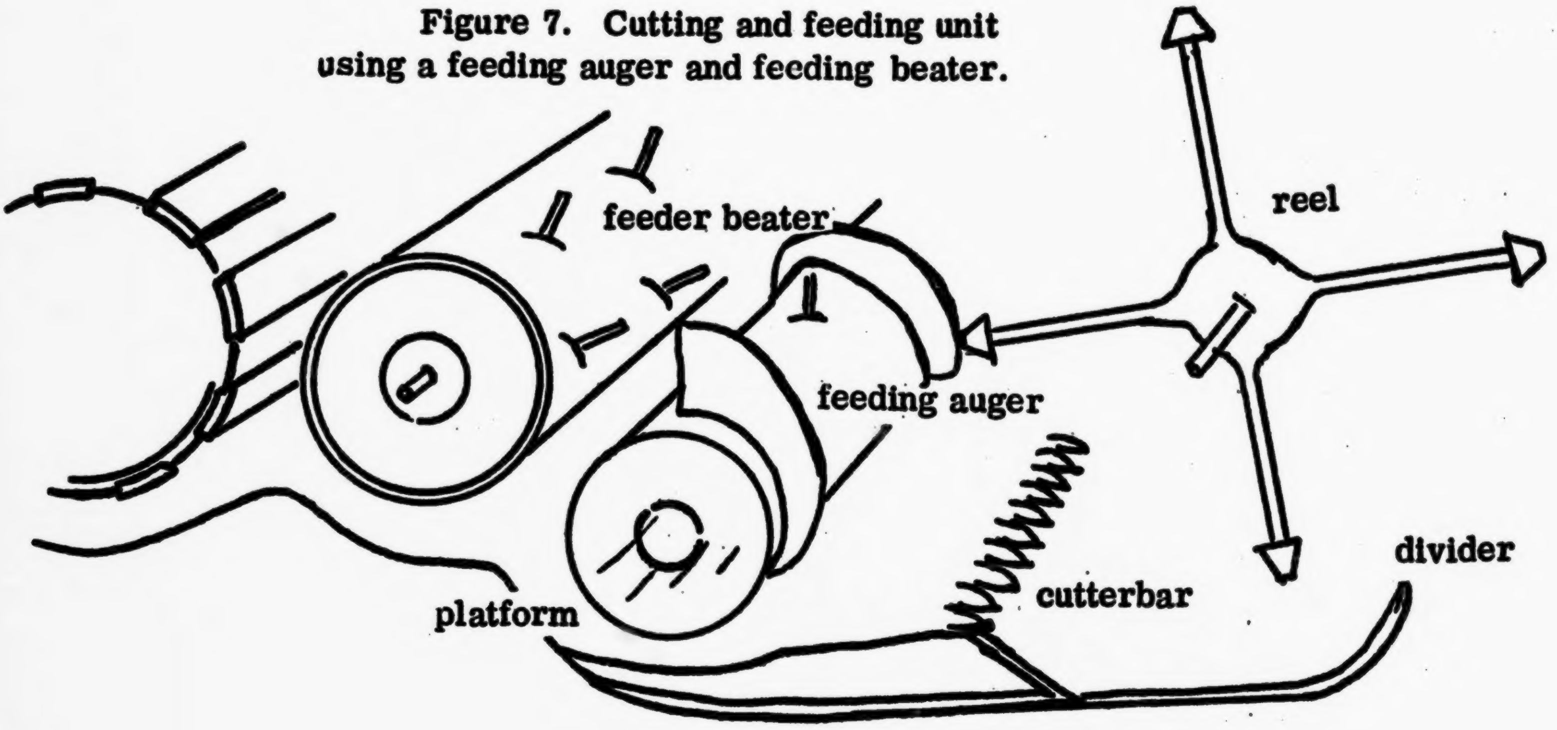
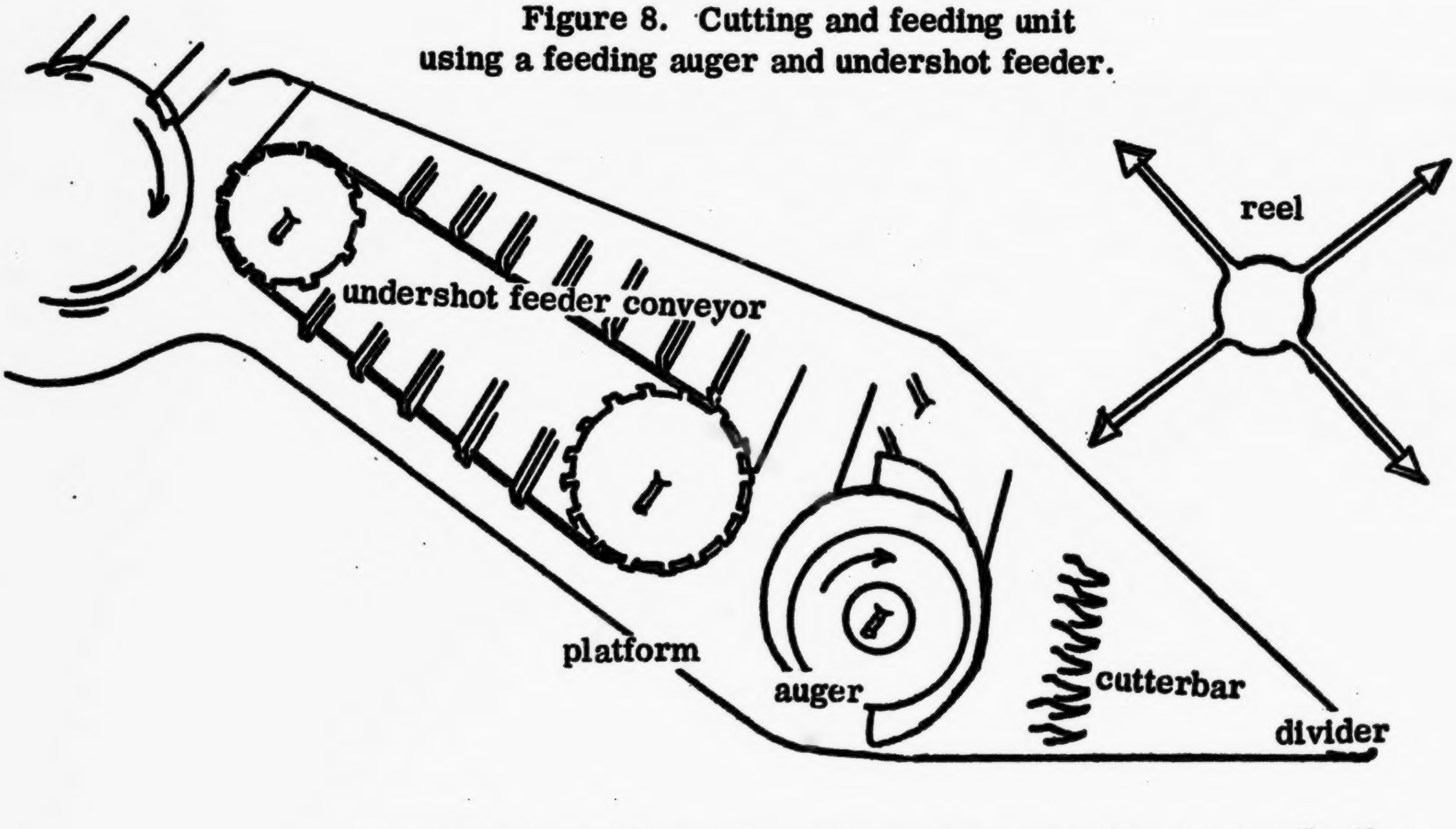

feeder beater
reel
feeding auger
divider
cutterbar
platform

Figure 7. Cutting and feeding unit using a feeding auger and feeding beater.

Figure 8. Cutting and feeding unit using a feeding auger and undershot feeder.


reel
undershot feeder conveyor
platform
auger
cutterbar
divider

Not all combines will perform this operation in exactly the same way. How is your combine designed to take care of the cutting and feeding operation?

The main parts in the cutting and feeding area are:

a. Cutter bar: The cutter bar works like a series of shears running through the field to cut the grain. This is accomplished by knife sections reciprocating (working back and forth) over ledger plates which are held in place by guards. Hold down clamps, wearing plates, and shims are used to keep the knife flat on the ledger plates. Figure 45.

The sickle bar is usually driven by a pitman drive assembly. Figure 53.

Power will usually be supplied to the pitman crank by means of a series of belts and chains.

b. Reel: The reel slats gather in the crop, hold it until it has been cut by the knife, and then move it onto the platform. The reel must be square, level, and at the proper height and position to feed the grain uniformly and steadily. The reel may be ground driven or power driven.

c. Platform: The platform holds the cutter bar and feeding mechanisms.

d. Cutting platform auger: The cutting platform auger moves the cut grain to the center of the platform where the retractable auger fingers feed the grain into the feeder conveyor or the feeder beater depending on the design of the combine.

e. Retractable finger feeder beater: In some combines the cutting platform auger is followed by a retractable finger feeder beater which moves the grain into either the feeder conveyor or into the threshing unit. Figure 7.

f. Feeder conveyor: The feed conveyor or feed rake, as it is sometimes called, is designed to feed the grain in a steady even flow into the threshing unit. Proper feeding into the threshing unit will cause less clogging.

g. Feeder beater: Some models of combines will have a feeder beater which takes the grain from the feed conveyor and feeds it uniformly into the threshing unit.

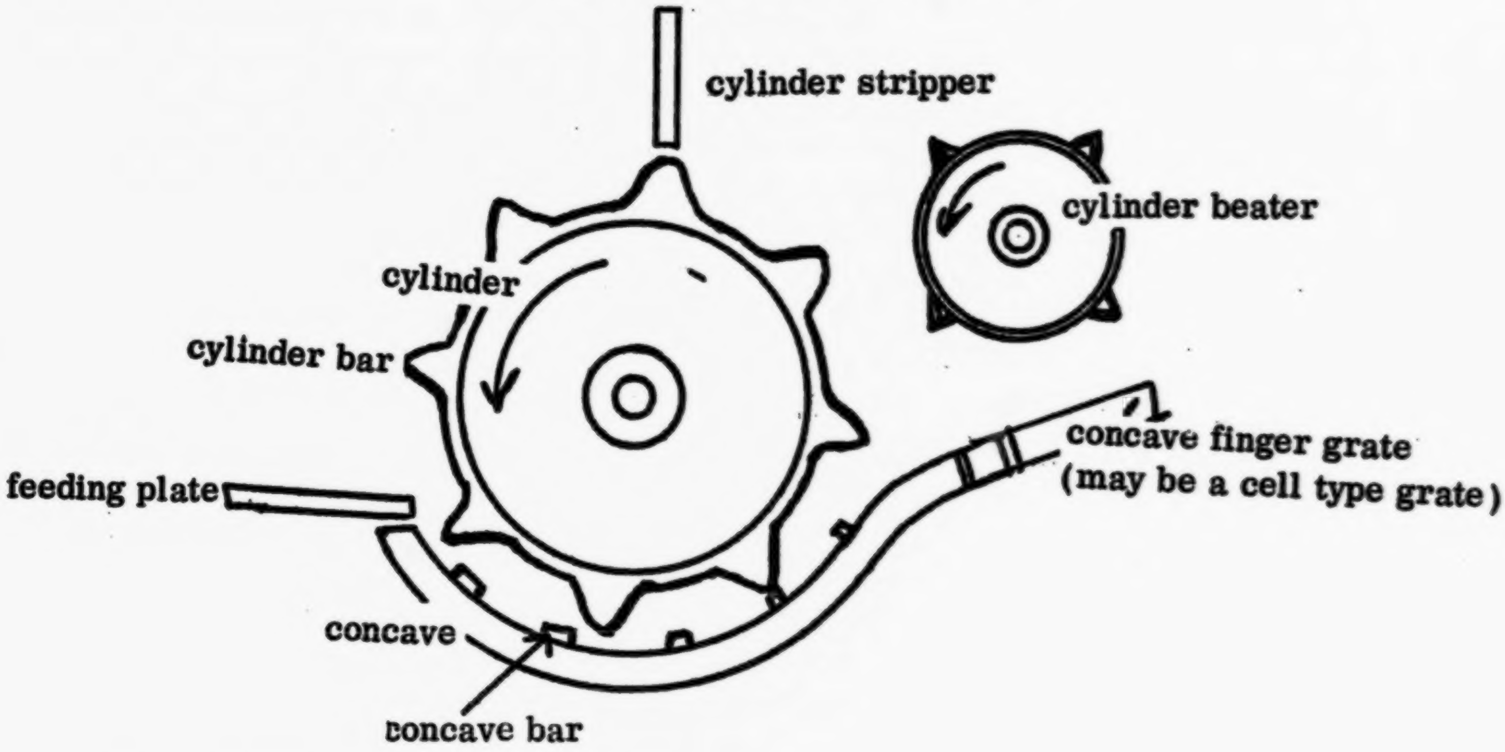
Student exercise: Study the combines you have in the school shop or at home, and make a schematic drawing of the cutting and feeding areas. Label all the parts and describe the flow of the grain. Use the operator's manual for the machine to help you.

2. Threshing Unit. Figure 9.

The function of this section of the combine is to thresh the grain from the heads. This is done by passing the grain between a rapidly revolving cylinder and a stationary surface underneath which is called the concave. The rubbing action on the grain caused by the bars on the cylinder passing over the concave channel bars causes the grain to be removed from the head.

The principle of threshing will be the same for all combines, but different makes and models will use different design and methods of making adjustments

Figure 9. THRESHING UNIT


cylinder stripper
cylinder beater
cylinder
cylinder bar
concave finger grate
(may be a cell type grate)
feeding plate
concave
concave bar

The design of some of the parts shown on this schematic diagram may be different on your combine. Some combines will not have a separate shelling plate and may not have finger grates.

The main parts of the threshing unit are:

a. Cylinder: The cylinder will have either bars or spikes that will cause the rubbing of the grain against the concave.

  (1). Rasp bar cylinder: The cylinder bars are rasp shaped as shown in the illustration. Figure 10.

  (2). Rub bar cylinder: The cylinder bars are angle shaped and faced with rubber. Figure 11.

  (3). Spiked tooth cylinder: The cylinder has spikes instead of bars. This type is not suited for corn harvesting. Figure 12.

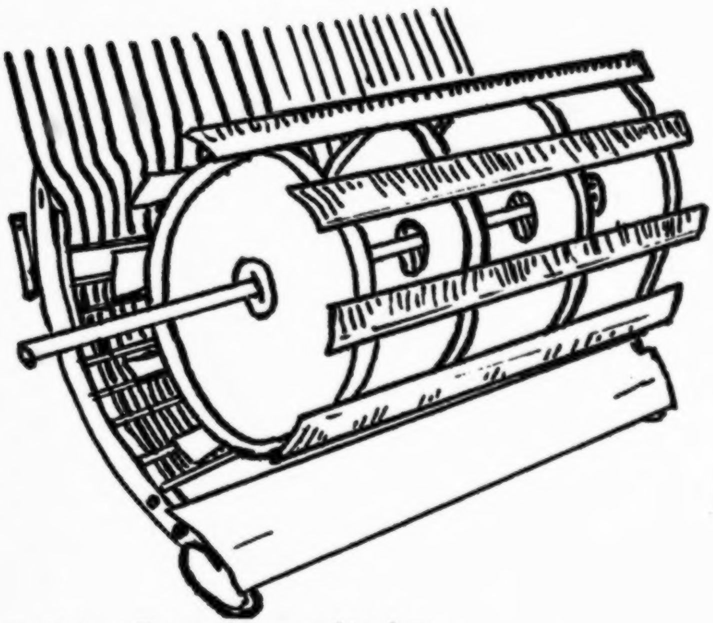


Figure 10. Rasp bar cylinder.

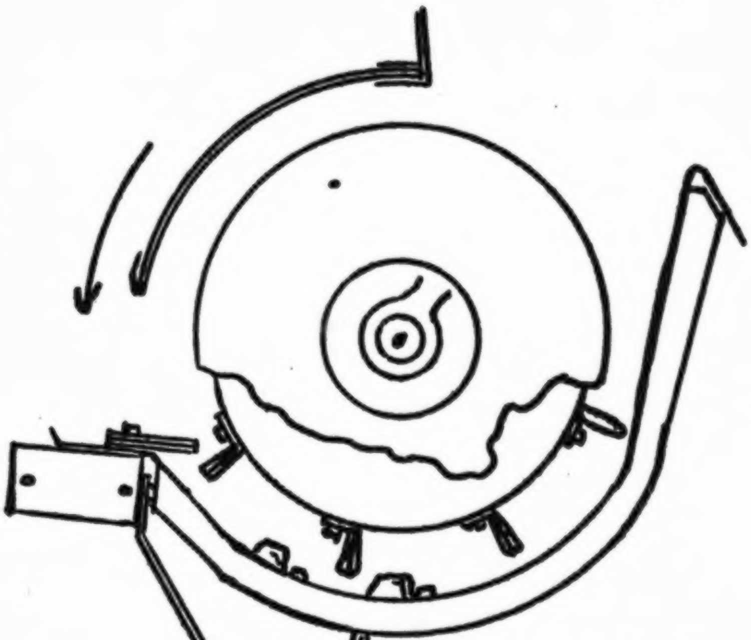


Figure 11. Rub bar cylinder.

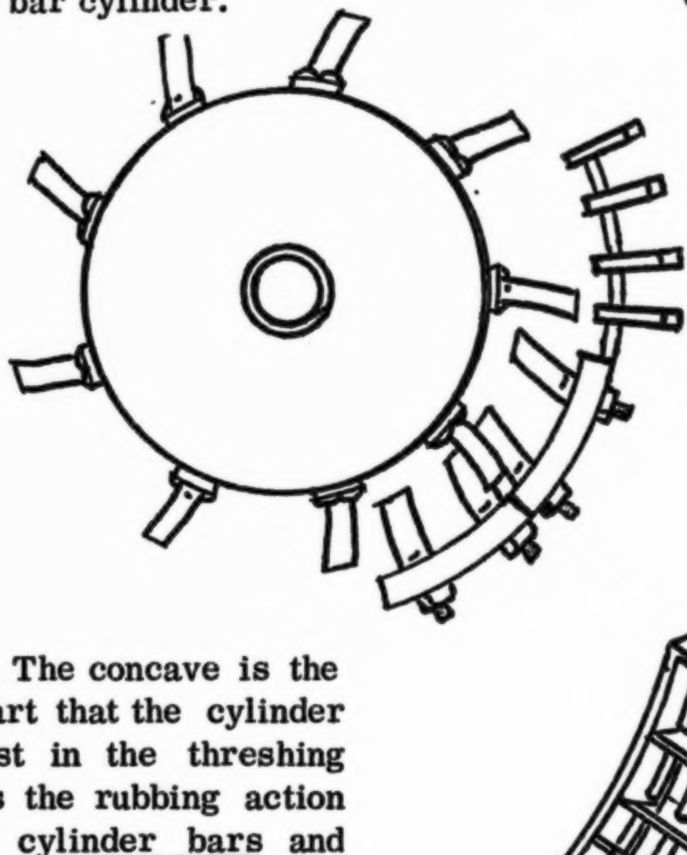


Figure 12. Spiked tooth cylinder.

b. Concave: The concave is the stationary part that the cylinder works against in the threshing action. It is the rubbing action between the cylinder bars and the concave bars that removes the seed from the head or pod. The concave is a grate composed of rods and bars or wires. (Figure 13.) It is at the concave grate and finger grate that as much as 90% of the grain is separated from the grain or husk. The separated grain falls through the grate onto the shoe pan where it is delivered to the cleaning unit. The straw and the remaining grain pass on into the separation unit. One make, the Gleaner combine, separates the grain from the straw by use of a raddle located behind the cylinder. Clean grain falls through the suspended straw and is conveyed to the cleaning shoe. (See figure 17.)

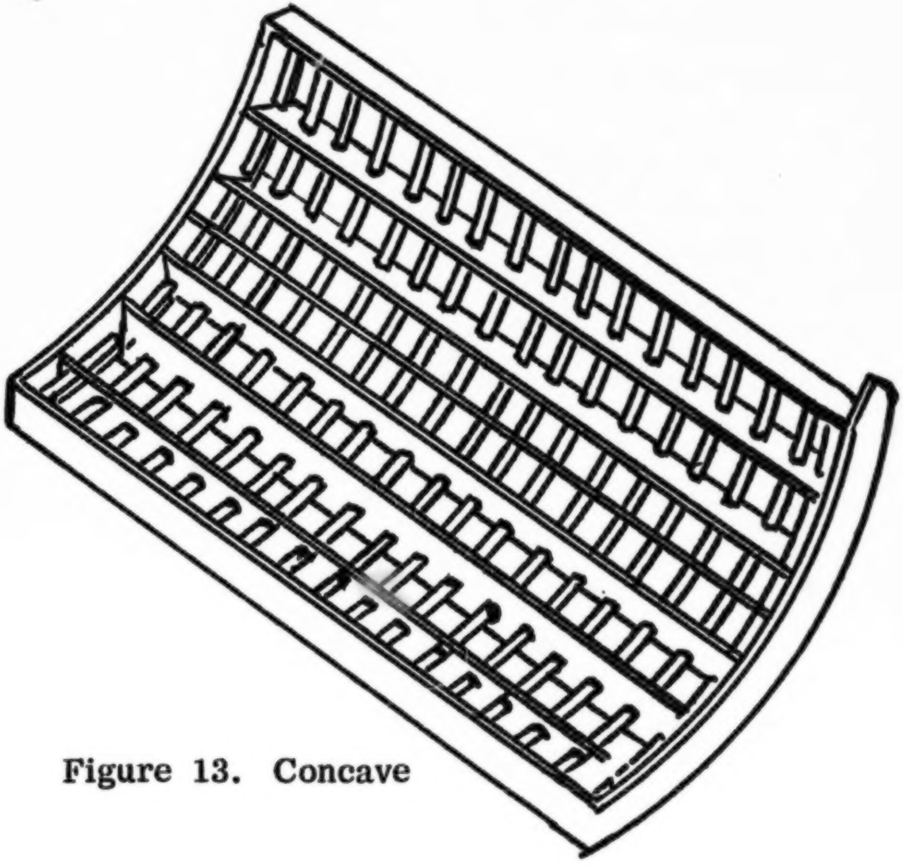


Figure 13. Concave

c. Cylinder beater: The beater behind the cylinder slows down the material coming from the cylinder, tears apart the straw, and delivers the material to the straw rack or the straw walker as it may be called. The beater helps in cleaning the straw from the cylinder thus preventing cylinder wrapping and feed back. Figure 9.

d. Feeding plate: The feeding plate (figure 9) is an adjustable plate located where the cut grain is fed into the cylinder concave unit. Much of the threshing can be done here.

e. Cylinder stripper: The cylinder stripper is set parallel to and above the cylinder and prevents back feeding.

3. Separating Unit.

The separating unit agitates the straw after it comes from the threshing unit. This shakes out the loose grain remaining in the straw and delivers it to the cleaning unit. Since the threshing unit separates up to 90% of the grain, only about 10% remains to be separated in this unit. The straw is carried out of the combine by the rack.

There are several designs used to collect the grain from the straw rack and concave grate. The schematic drawings in figures 14, 15, 16 and 17 show four possible methods of doing this.

Figure 14. Separating unit using straw rack return pan under the straw rack.

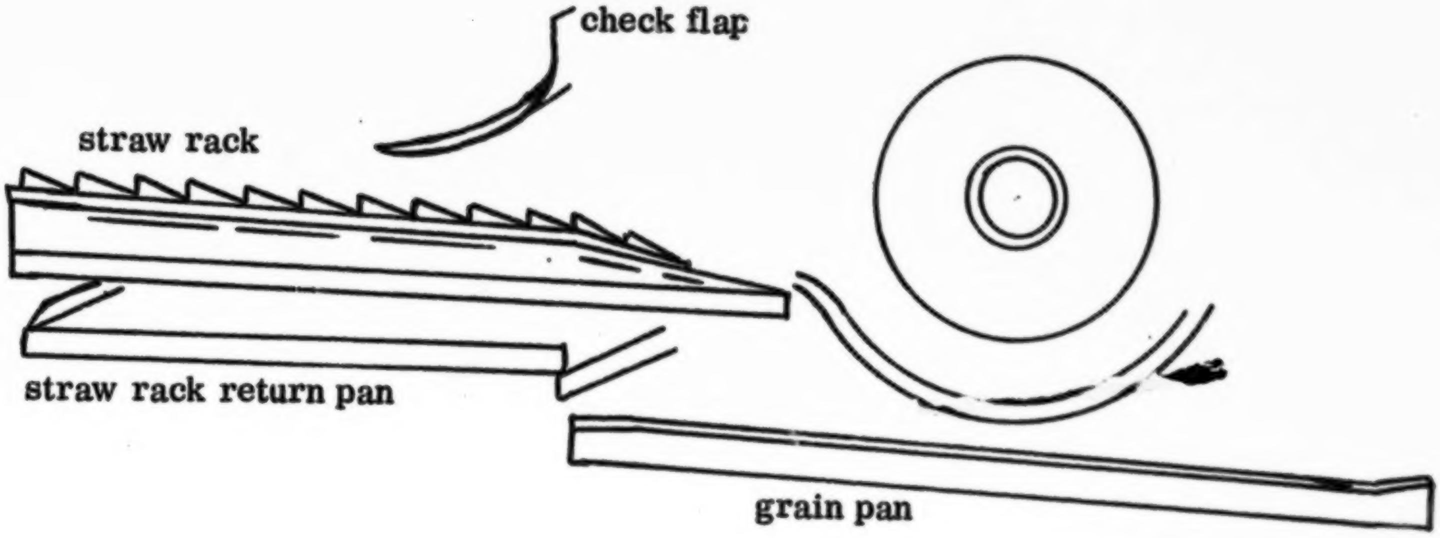


Figure 15. Separating unit using straw rack return pan and grain conveyor.

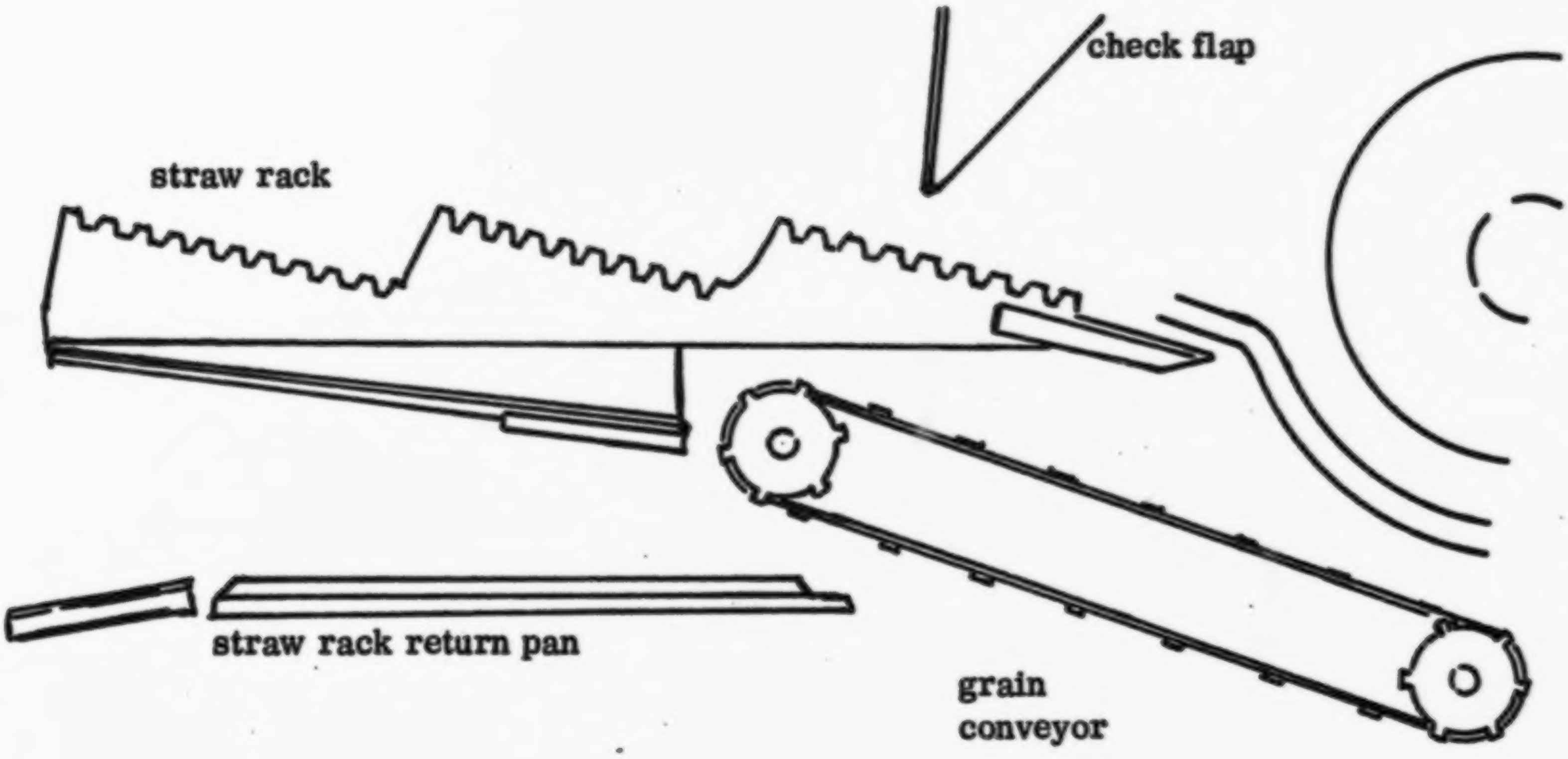

check flap
straw rack
straw rack return pan
grain
conveyor

Figure 16. Separating unit using grain return conveyor under the straw rack.

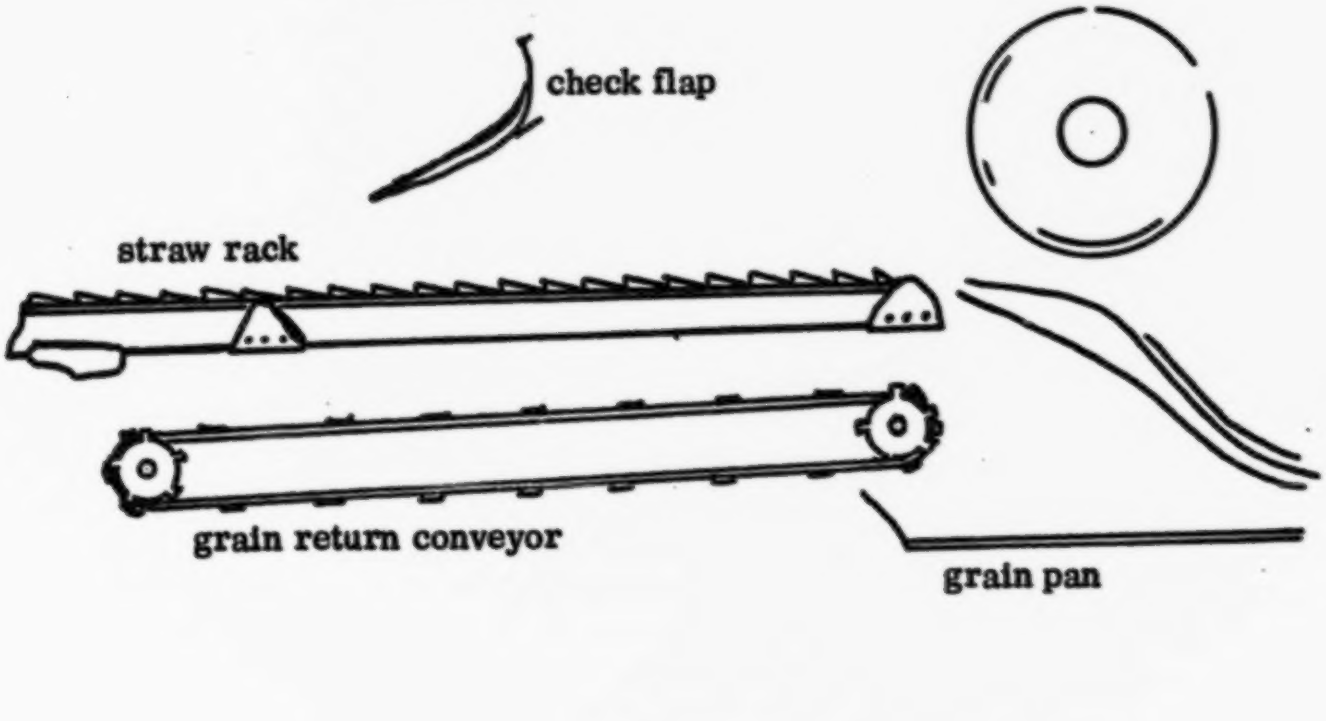
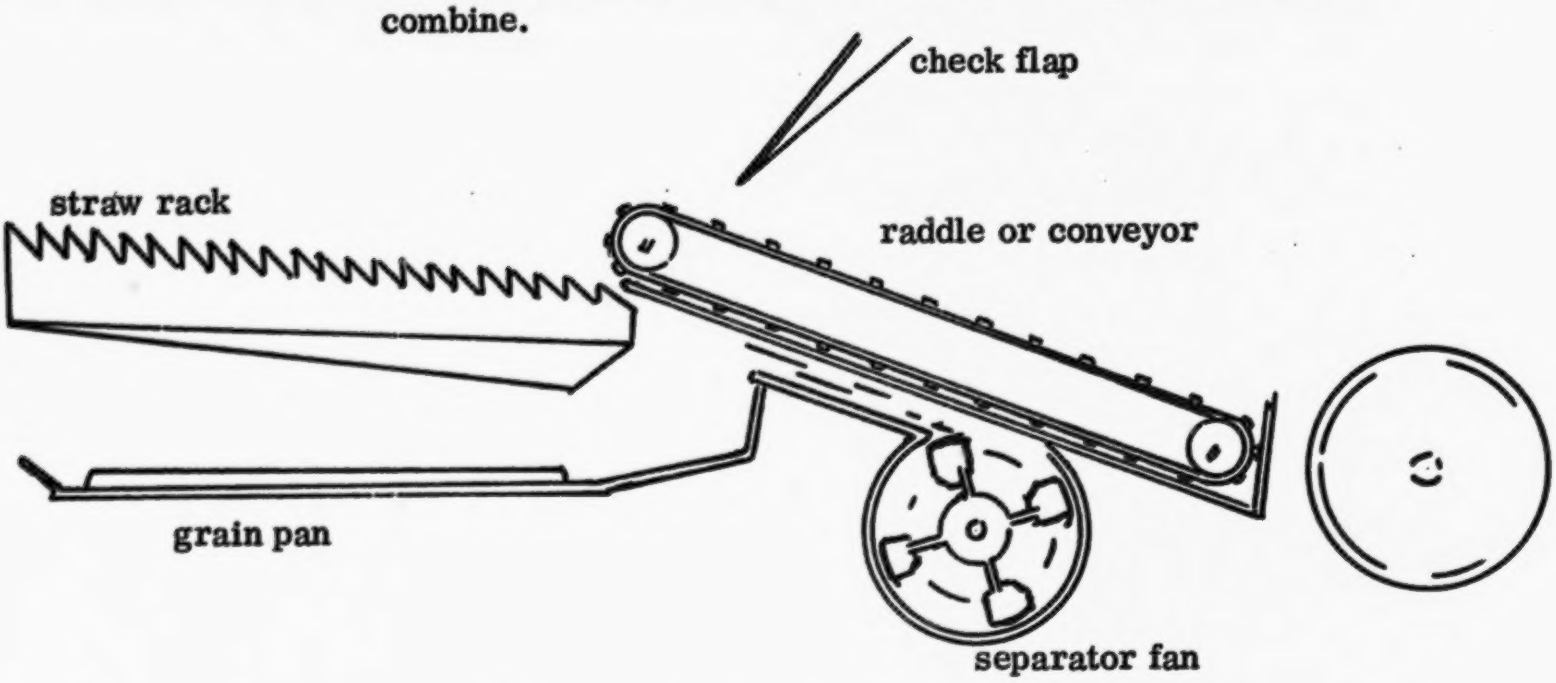

check flap
straw rack
grain return conveyor
grain pan

Figure 17. Separating unit using a grain return pan under the straw rack. A cleaning fan is also used in the separating section of this combine.

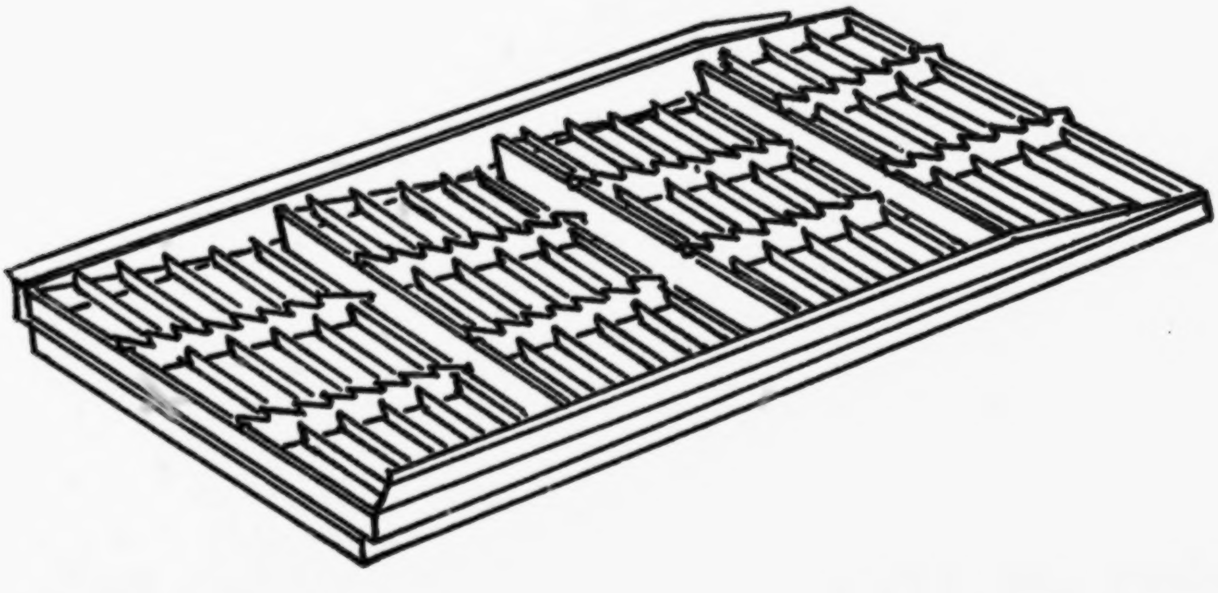


The main parts of the separating area are:

a. Concave grate and finger or cell grate which has been described in the threshing unit.

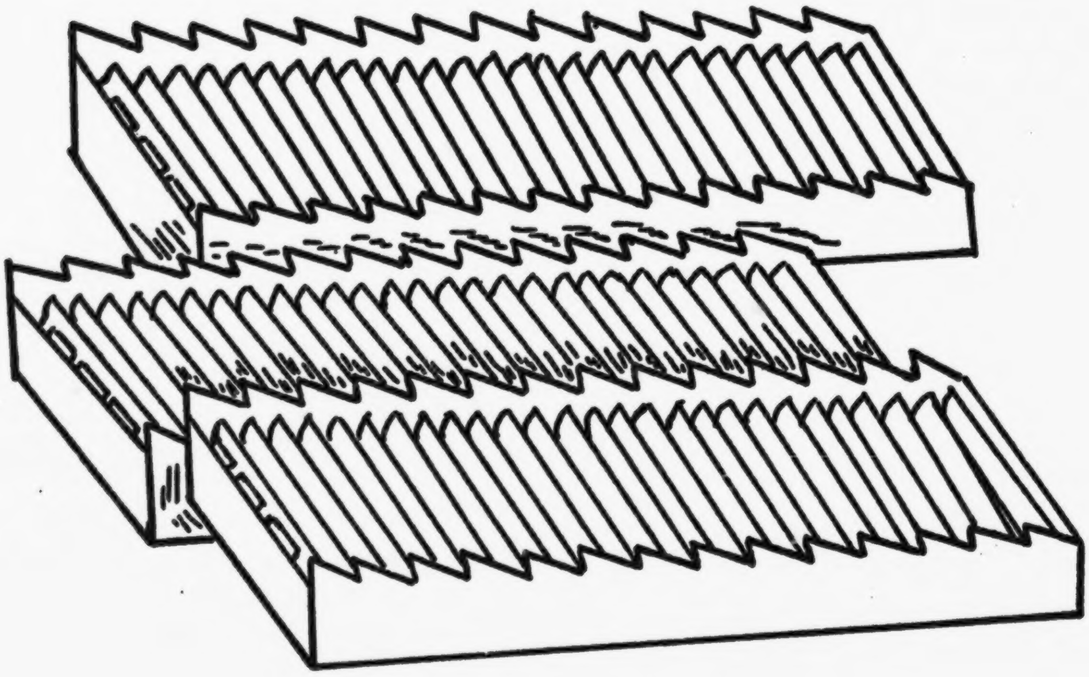
b. One piece straw rack: The straw rack is a one piece unit with risers pointed toward the rear of the combine. Figure 18. The straw rack is mounted on cranks located at the front and rear which give it an oscillating motion. As the rack moves rearward and upward the straw is tossed up and to the rear. As the rack returns forward and downward the straw stays in mid air for a short time and then falls onto a section of the rack nearer the end of the combine. In this way the straw moves step by step out of the combine. This tossing action causes the grain to be separated from the straw.

Figure 18. One piece straw rack.



c. Walker type straw rack: Some large combines may use a walker type straw rack which operates on the same principle as the rack. The straw walker has three or more narrow sections placed side by side. Each section is mounted on multiple throw cranks located at the front and rear. The crank throws for each section are equally spaced around the circle of rotation thus the sections do not operate as a unit as the rack does. Figure 19.

Figure 19. Walker type straw rack.



d. Grain return pan: The grain return pan is located under the straw rack. It catches the grain as it falls through the rack and moves forward to the grain pan. The straw walker usually has a return pan under each unit. Figures 14 and 15.

e. Grain return conveyor: In place of the grain return pan some combines will use a conveyor to catch the grain and move it forward. Figure 16.

f. Grain pan: The grain pan is usually located under the forward part of the straw rack behind and below the cylinder. Its function is to catch the grain from the concave and cylinder grates and from the grain return pan or conveyor for delivery to the cleaning unit. Figures 14 and 16.

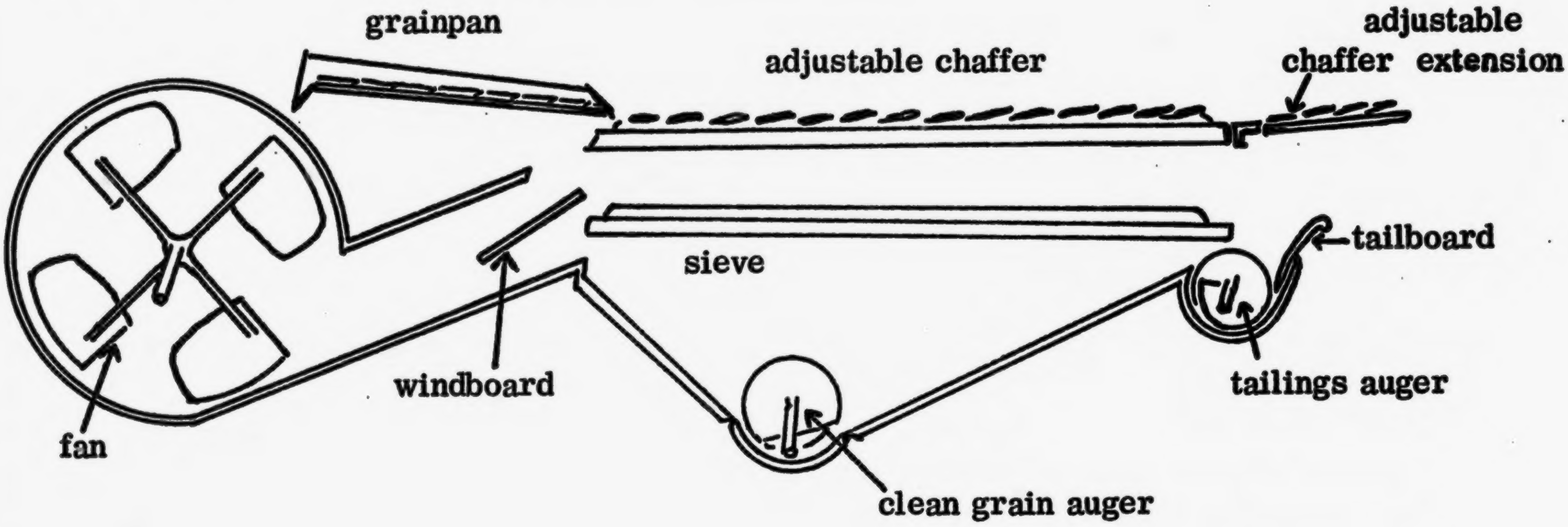
g. Grain conveyor: Some combines will use a conveyor in place of the grain pan to collect and deliver grain to the cleaning unit. Figure 15.

h. Check flaps or curtains: The check flaps or curtains deflect the straw and grain onto the rack as the full length of the rack is used for separation. They should not be in the way of the straw as the rack moves it to the rear.

Student exercise: The basic principles of separation are the same in all combines. However, different makes and models will have different designs. Prepare a schematic diagram of the separating unit of your combine after studying both the combine and the operator's manual. Explain the basic principles of separation.

4. **Cleaning unit:** The function of this unit is to separate the clean grain and send it to the grain tank, return the tailings (partially threshed heads) to the cylinder for rethreshing, and move the remaining material out of the combine. This is accomplished by means of gravity and air blast. Figure 20.

Figure 20. Cleaning unit.


grainpan
adjustable chaffer
adjustable chaffer extension
tailboard
sieve
windboard
tailings auger
fan
clean grain auger

a. **Adjustable chaffer:** The adjustable chaffer acts as a sieve. It is made up of a series of cross pieces mounted on rods and fastened together so they can be moved at the same time to adjust the size of the openings. Figures 20 & 21.

Figure 21. Side and flat views of the chaffer showing how the lips may be adjusted to control the amount and kind of materials passing through.

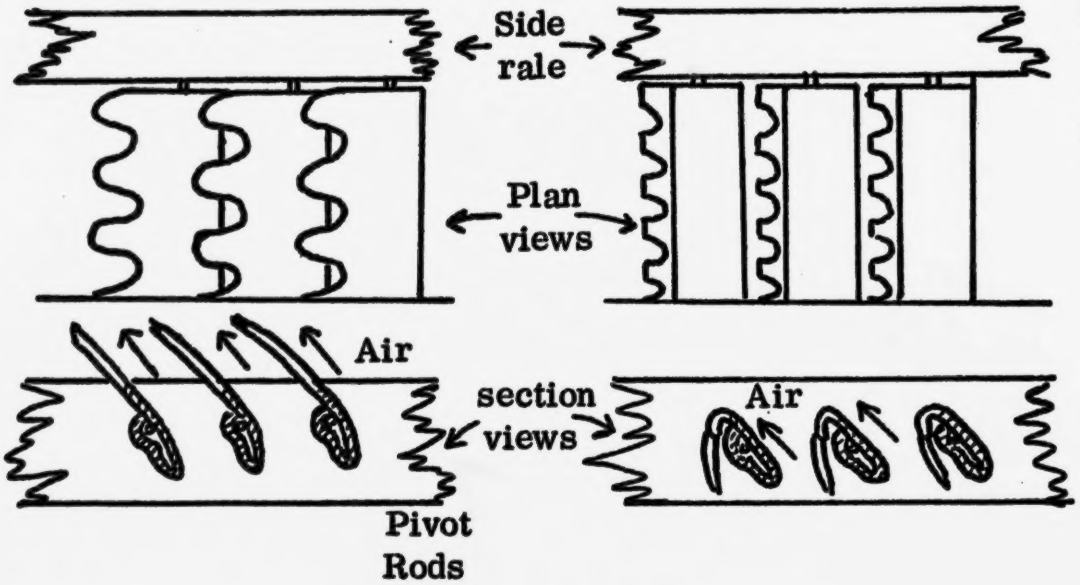

Side rale
Plan views
Air
section views
Air
Pivot Rods

Figure 21. Partial views of two types of adjustable chaffer sieves.

b. Chaffer extension: As the name suggests this is an extension of the chaffer. In addition to having adjustable lips the chaffer extension will also swing up and down on the end of the chaffer. The unthreshed portions of grain heads fall through the chaffer extension into the tailings auger. The bulky material passes over the chaffer extension and out of the combine. Figure 22.

c. Sieve: The sieve is like the chaffer except that the lips and openings are smaller. The final job of cleaning is done here. The material that is too large to pass through the sieve is carried over the the tailings auger and returned to the cylinder for rethreshing. Figure 22.

d. Special chaffer and sieve equipment: Many combines will have special screens available for some crops that are difficult to clean.

e. Cleaning fan: The fan furnishes a blast of air. The strength of the air blast is controlled by the speed of the fan and by shutters in the air intake. The direction of the air blast is controlled by windboards. The function of the air blast is to keep the material "alive" on the chaffer and sieve. The air blast should be strong enough to lift the chaff slightly off the chaffer and sieve, but not strong enough to blow grain out of the combine.

f. Clean grain auger and clean grain elevator: The clean grain auger collects the cleaned grain and augers it to the clean grain elevator which delivers the clean grain to the grain tank.

g. Tailings auger and tailings elevator: The tailings auger collects all of the material which comes off the lower sieve plus any material which falls through the extension chaffer.

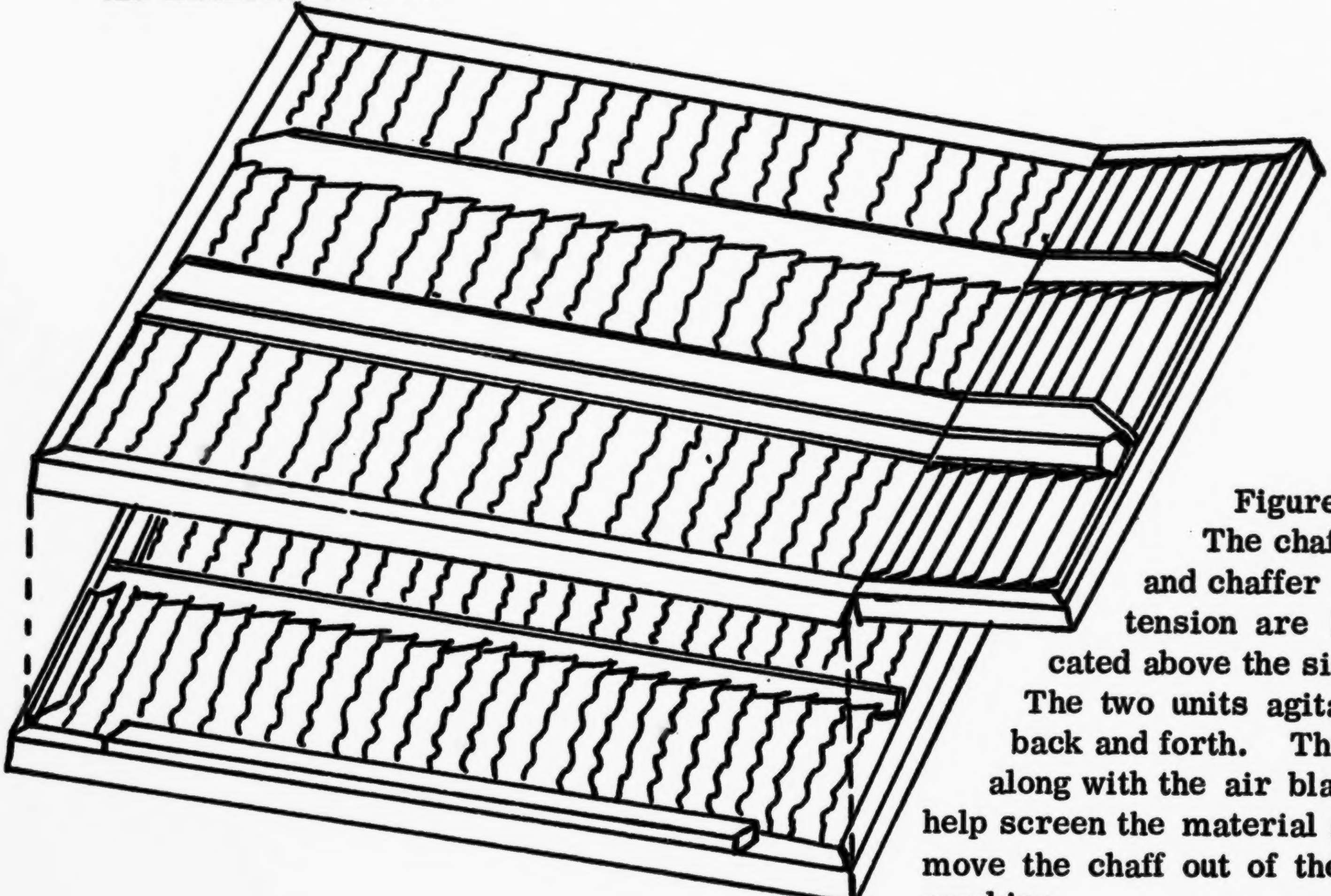


Figure 22. The chaffer and chaffer extension are located above the sieve. The two units agitate back and forth. This along with the air blast help screen the material and move the chaff out of the combine.

h. Tailboard: The tailboard keeps the unthreshed material from being carried out of the rear of the combine while still allowing the chaff to be blown out. It may be raised or lowered as needed.

Student exercise: Prepare a schematic diagram of the cleaning unit on your combine showing the basic parts of the cleaning section on your combine. What are the basic principles of the cleaning operation?

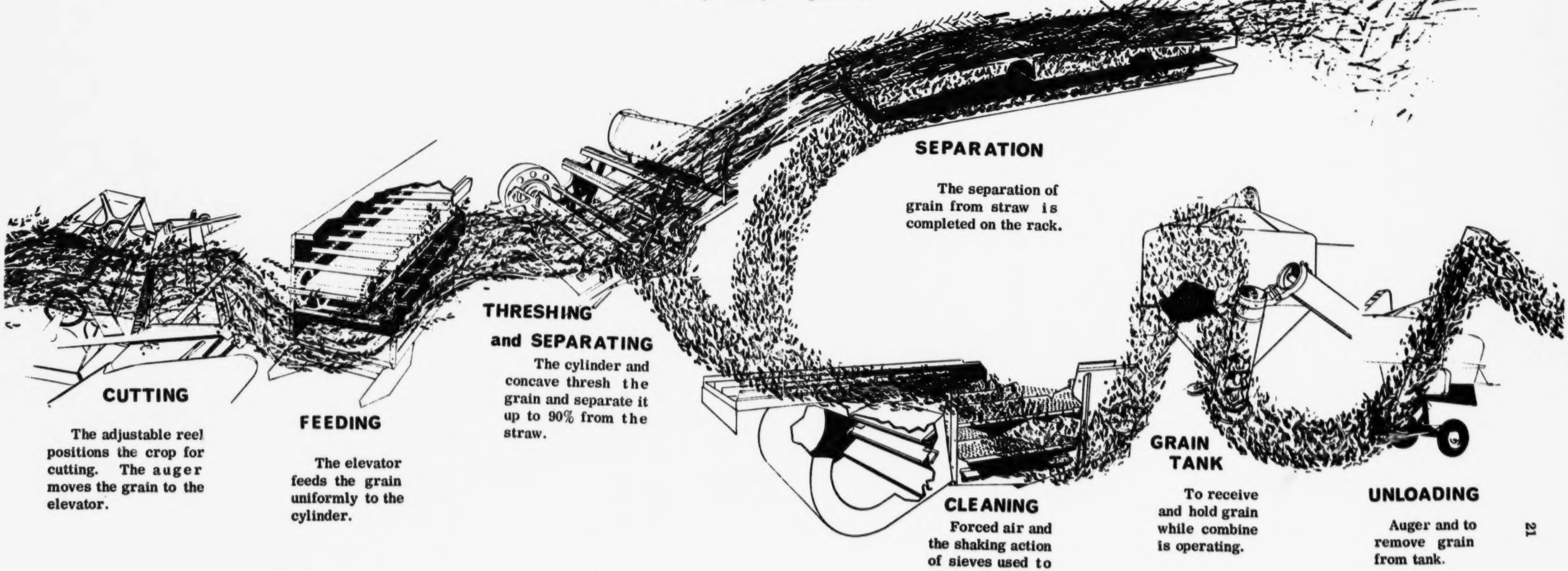
5. How do the four areas of the combine work together?

The four areas of the combine must work together if the machine is to be expected to do an efficient job of harvesting. The way one section is operated and adjusted will affect the efficiency of the remaining areas. The following laboratory exercise will help you to understand how the combine areas work together.

Student exercise: Now that you have completed the study of the four basic areas of the combine — cutting and feeding, threshing, separating, and cleaning — turn to figure 23 and see how the material flows from one area of the combine to the next. Keep in mind that all combines will have each of these basic areas but may use different mechanical design to carry out the necessary work. After becoming familiar with the principal parts and their functions turn to figure 24, and see if you can name them. (Do not write in this book unless your teacher tells you to.)

Do you know how the material moves through the combine and the process that takes place in each of the sections? Turn to figure 25 and study the flow chart to see how the material moves through the machine. A look back to figure 5 (combine cross section) may help you. Next see of you can trace the flow of material through a combine in the school shop or at home. Use the blank flow chart in figure 26 while doing this.

Figure 23. FLOW OF MATERIALS THROUGH THE COMBINE.
Courtesy Massey-Ferguson Co.



CUTTING

The adjustable reel positions the crop for cutting. The auger moves the grain to the elevator.

FEEDING

The elevator feeds the grain uniformly to the cylinder.

THRESHING and SEPARATING

The cylinder and concave thresh the grain and separate it up to 90% from the straw.

SEPARATION

The separation of grain from straw is completed on the rack.

CLEANING

Forced air and the shaking action of sieves used to clean the grain.

GRAIN TANK

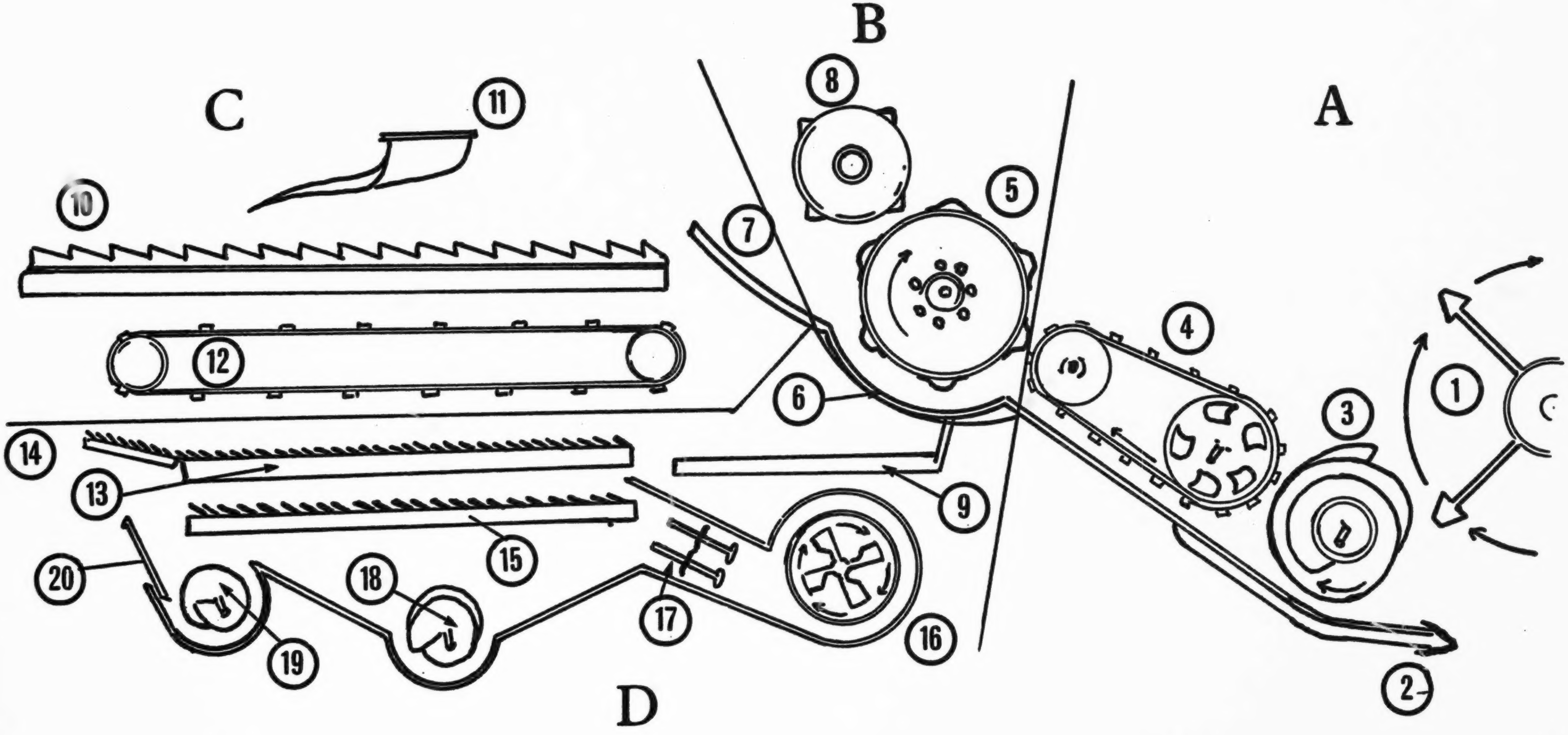
To receive and hold grain while combine is operating.

UNLOADING

Auger and to remove grain from tank.

Figure 24. COMBINE CROSS SECTION

Write in the names of the parts of the combine that are indicated by the numbers on the drawing of the combine. Use the blanks below the drawing.


A
B
C
D
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Sections of a Combine: A________________; B________________; C________________; D________________

	Section		Section		Section		Section
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

FIGURE 25 COMBINE FLOW CHART

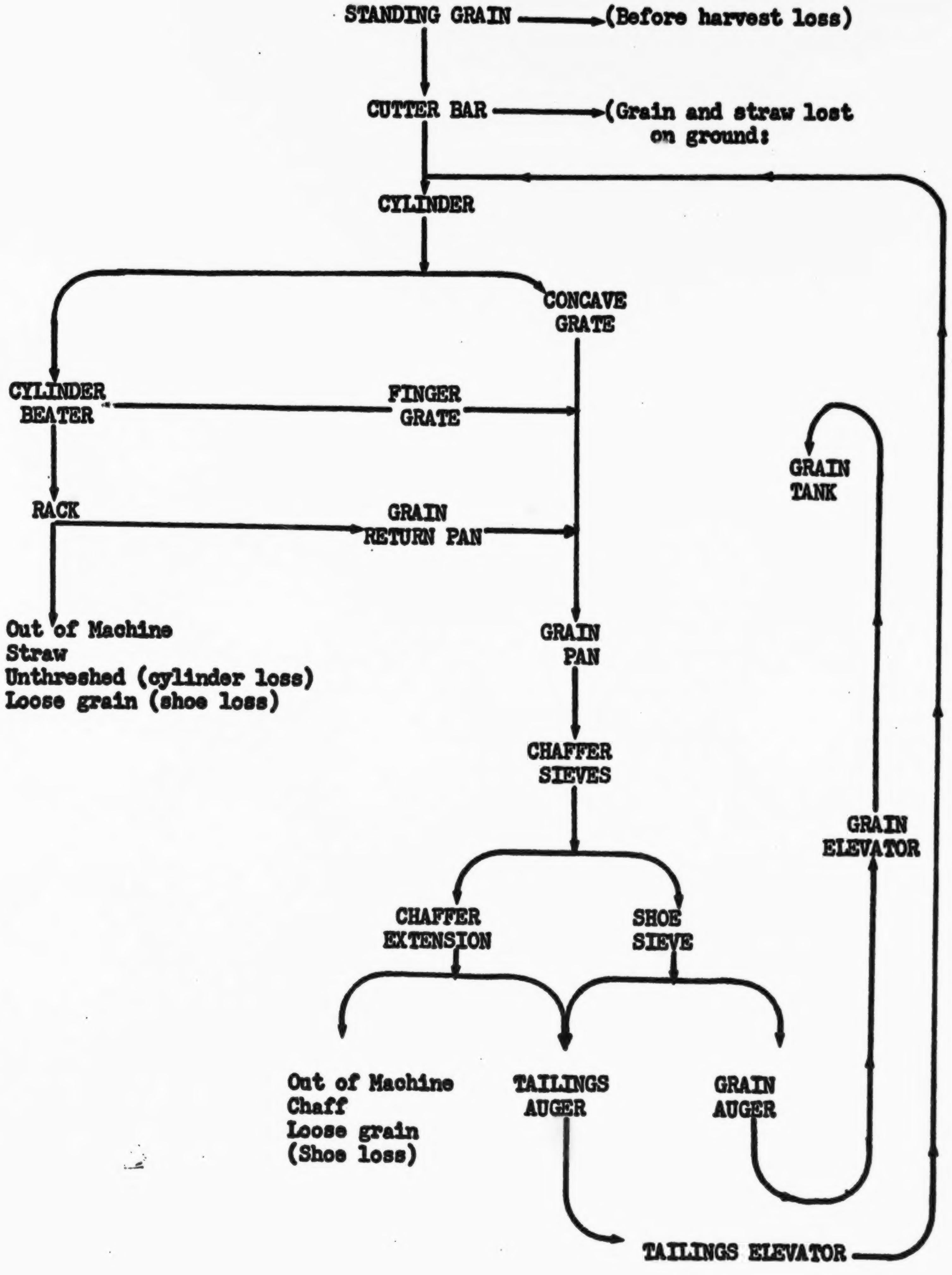

STANDING GRAIN
(Before harvest loss)
CUTTER BAR
(Grain and straw lost on ground:
CYLINDER
CONCAVE GRATE
CYLINDER BEATER
FINGER GRATE
RACK
GRAIN RETURN PAN
Out of Machine
Straw
Unthreshed (cylinder loss)
Loose grain (shoe loss)
GRAIN PAN
CHAFFER SIEVES
GRAIN TANK
GRAIN ELEVATOR
CHAFFER EXTENSION
SHOE SIEVE
Out of Machine
Chaff
Loose grain
(Shoe loss)
TAILINGS AUGER
GRAIN AUGER
TAILINGS ELEVATOR

FIGURE 26 COMBINE FLOW CHART

SKETCH THE PATH OF MATERIAL THROUGH YOUR COMBINE

Name________________________

STANDING GRAIN

CUTTER BAR

CYLINDER

CONCAVE
GRATE

CYLINDER
BEATER

FINGER
GRATE

GRAIN
TANK

RACK

GRAIN
RETURN PAN

Out of Machine
1. ________________
2. ________________
3. ________________

GRAIN
PAN

CHAFFER
SIEVES

GRAIN
ELEVATOR

CHAFFER
EXTENSION

SHOE
SIEVE

Out of Machine
1. ______________
2. ______________

TAILINGS
AUGER

GRAIN
AUGER

TAILINGS ELEVATOR

III. OPERATION OF THE COMBINE.

If you are operating or intend to operate a combine it will be important for you to understand the sources and causes of grain loss and the adjustments that should be made to correct these losses. The quality of the job of combining you will be able to do will depend on your understanding of these adjustments and your ability to make the proper adjustments in the field when you are operating your combine.

This section of the manual should help you become familiar with the basic principles of some of the common adjustments to meet different operation conditions. You should also have a copy of the manufacutrer's operator's manual to use with the combine you are studying in this exercise. It will give you the specific adjustments for the machine you are working with.

A. SOURCES OF GRAIN LOSS FROM THE COMBINE.

Each of the four separate areas of the combine - cutting and feeding, threshing, separating, and cleaning - can be a source of loss. The losses in these areas are usually known as the cutter bar, cylinder, rack, and shoe losses.

1. Cutter bar loss: Any or all of the following items may cause cutter bar loss.

a. Heads of grain missed by the cutter bar.
b. Grain shattered out of the head as the knife cuts the straw.
c. Grain cut and dropped to the ground before reaching the feeding platform.
d. Grain shattered out when the reel strikes the standing grain.
e. Heads of grain thrown out by the reel.

The grain that has been shattered onto the ground ahead of the combine should not be included with the cutter bar loss.

2. Cylinder loss: The cylinder can cause loss in two ways. They can be identified as follows:

a. Unshelled grain left in the heads and carried to the rear of the combine by the rack.
b. Cracked grain in the grain tank caused by the cylinder running too fast or the concave cylinder clearance being too close.

3. Rack loss: The rack loss is the loose grain which has not been separated from the straw as it passes over the rack and is carried out of the machine with the straw.

4. Shoe loss: The shoe loss is the grain that is carried over the rear of the sieves with the chaff or blown out of the combine with the fan.

The four losses taken together will show how good a job of combining you are doing.

5. How much loss can be expected: Losses, with the best combine adjustment, will vary greatly depending upon the type, variety, and the condition of the crop. Total losses in clean crops of wheat, oats, barley, and rye will vary from approximately 1% to 4% of the total yield. Under good harvesting conditions the total loss should not be more than one and one-half percent.

a. Small grain losses: Under average conditions the following range of losses might be expected when small grain crops are harvested.

(1) Cutter bar loss .5% to 2%. When the combine is properly adjusted this will usually be higher than for the other parts of the combine.
(2) Cylinder loss .5% to 1%. It is usually best not to reduce cylinder loss below .5% because rack shoe losses will increase rapidly if the straw is over threshed.
(3) Rack loss .2% to .4%.
(4) Shoe loss .2% to .4%.

b. Soybeans: Researchers at the Ohio Agricultural Experiment Station ran tests on farmer operated combines, under typical harvesting conditions, for a period of seven years. These tests show that the following results might be expected.

(1) Cutter bar loss 12.6%. This loss included the following:

(a) Beans shattered onto the ground.
(b) Beans remaining in pods on the stubble.
(c) Beans remaining in pods on stalks which had been cut off but not fed into the machine.
(d) Beans in pods on lodged stalks.

(2) Cylinder loss .96%. Nearly all of the beans are threshed out by the cylinder.
(3) Rack and shoe 1.0%. The separating and cleaning area did not have serious losses.

The total loss for the seven year test ranged from 8.8% to 19.3% of the total crop.

c. Corn: Research at the Ohio Agricultural Experiment Station shows that the following losses might be expected when harvesting corn.

- (1) Gathering Unit
    - Lost ears 1% - 20%
    - Snapping roll loss 1% - 5%
- (2) Cylinder loss 0 - 5%
- (3) Rack and shoe .5% - 5%
- (4) Cracked kernels .5% - 4%
- (5) Invisible loss 0% - 5%

B. HOW COMBINE LOSSES CAN BE MEASURED.

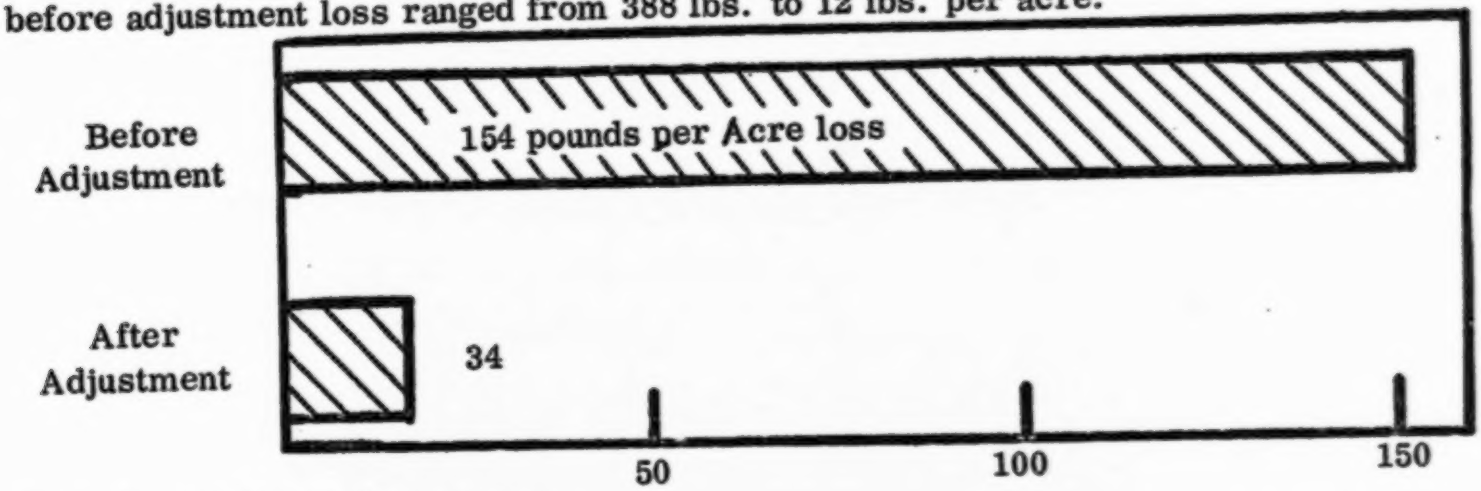
Each of the four areas of the combine - cutting and feeding, threshing, separating, and cleaning - has its own adjustments. The first step in finding out what machine adjustments are needed to improve your job of combining is to measure the amount of loss from each of the combine areas. This can be done accurately on most crops except grasses and legumes by the method used by the Ohio Agricultural Experiment Station.[2] A simpler, although less accurate, method is described in this manual.

1. Will it be worthwhile for you to check your combine losses to find the adjustments you should make to correct them?

The Ohio Agricultural Experiment Station conducted tests with combines being operated by farmers to harvest wheat. Each of these machines was out of adjustment in some way. The harvesting losses were checked on the machines as they were being run by the operators. The needed adjustments were made,and the harvesting losses were checked again. A summary of these tests is shown in figure 27. It should be mentioned that another machine being operated by a farmer was only loosing two pounds of wheat per acre.

FIGURE 27. ADJUSTING COMBINES REDUCES GRAIN LOSSES

Losses checked on eight combines before and after making adjustments. The before adjustment loss ranged from 388 lbs. to 12 lbs. per acre.



Grain losses in pounds per acre.

From Ohio Agricultural Experiment Station

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[2] G. W. McCuen and E. A. Silver, Combine Harvester Investigations, Bulletin 643, The Ohio Agricultural Experiment Station.

2. Figuring the harvesting loss per acre.

The bushels of grain lost per acre can be estimated by collecting the number of kernels lost in a measured test area. The test area should contain about 50 square feet for small combines and about 100 square feet for large combines. Smaller areas may be used by increasing the number of samples to maintain accuracy.

The test areas can be set up as follows: Measure the distance on the ground that the combine will need to travel in cutting the desired number of square feet. Mark this distance by setting stakes beside the standing grain. Example: a 12 foot combine will travel 8 feet 4 inches in cutting 100 square feet of grain. (Figure 28.) The material can be collected in a box or on canvas as the combine passes through this area and the kernels of grain separate from the chaff and straw. If the combine has a straw spreader it will need to be disconnected during the test.

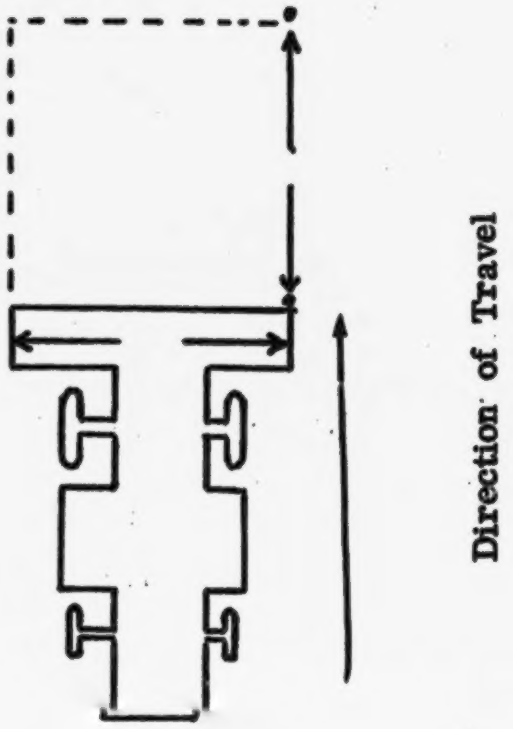

Figure 28. Measuring the test area for checking combine harvesting loss.

The kernels collected in the test area can be changed to bushels per acre by one of the following methods:

a. Counting the kernels.

(1) Count the kernels found in the test area.
(2) Find the number of kernels per square foot.
(3) Divide the kernels per square foot by the number of kernels per square foot equal to one bushel loss per acre found in table 1. This will give you the loss in bushels per acre.

Example: In checking soybean harvesting loss, 400 soybeans were picked up from a 20 square foot test area. What is the loss in bushels per acre?

$$\frac{\text{400 soybeans}}{\text{20 sq. ft.}} = \text{20 soybeans per sq. ft.}$$

$$\frac{\text{20 soybeans per sq. ft.}}{\text{5 kernels per sq. ft.}} = \text{4 bu. per acre loss.}$$

Table 1. Approximate Number of Kernels Per Square Foot to Equal One Bushel Loss Per Acre

Crop	Approximate Number of Kernels Per Square Foot
Wheat	18 - 20
Oats	10 - 12
Soybeans	4 - 5
Barley	13 - 15
Rye	21 - 24
Corn	2

The Ohio State University, Department of Agricultural Engineering.

If losses are high you must count large numbers of kernels which would require too much time. You may want to use the following method.

b. Measuring the kernels: Calibrated plastic tubes may be used to change the volume of kernels collected from the test area to loss in bushels per acre. Glue one end of a clear plastic tube to a block of wood. (See figure 29.) The position of the calibration marks will depend on the square feet of ground in the test area and the inside diameter of the plastic tube. Table 2 shows the volume required to equal one bushel loss per acre from a given test area.

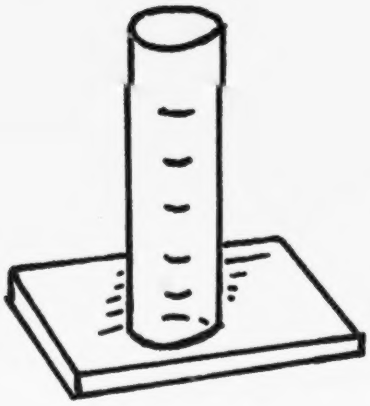

Figure 29. Calibrated plastic tube for measuring bushel per acre grain loss.

Table 2. Cubic Inches Required to Equal One Bushel Grain Loss Per Acre With Different Size Test Areas

Square feet of ground in test area	Volume in tube equal to 1 bu. per acre cubic inches
20	1
50	2 1/2
100	5

Example: If you have a plastic tube one inch in diameter how far apart will the calibration markings be to equal one cubic inch of volume in the tube.

Formula: Volume of a cylinder $= \pi r^2 h$

$$1 \text{ cu. in.} = 3.1416 \times (.5'')^2 \times X \text{ (height)}$$

$$1 \text{ qu. in.} = .7854 X$$

$$X = 1.27''$$

When a one inch inside diameter tube is used each 1.27 inches of height will equal one cubic inch of volume in the tube.

Problem: If you are using a 1 1/2 inch inside diameter tube what will be the inches in height required to equal 1 cubic inch of volume in the tube?

3. Finding the loss from each combine area: The following procedures may be used to find the loss from each of the four areas of the combine. The location and the kind of loss you find will show you the kind of adjustment that needs to be made to improve the efficiency of your combine.

a. Finding the cutter bar loss: Stop the combine and count the kernels of grain found on one square foot of ground under the machine including the kernels in unthreshed heads. Subtract from this the shattered kernels and grain in heads of grain on one square foot of ground in the standing grain in front of the cutter bar. The difference will be the cutter bar loss. For more accuracy use several square foot areas in each location. The loss per acre can be figured from Table 1.

Example: If fifteen kernels of wheat per square foot are found under the machine and five per square foot are found ahead of the cutter bar the cutter bar loss is 10 kernels per square foot or 1/2 bushel per acre. (Table 1.)

b. Finding the cylinder loss: The following steps may be used in finding the cylinder loss:

(1) Select the size test area you want to use and mark it off on the ground. (Follow the instructions given earlier in this section.)
(2) Catch all the material coming from the rear of the combine.
(3) Collect the heads that are all or partly unthreshed. Thresh these out and measure the approximate loss in bushel per acre by one of the methods described.
(4) Examine the material for an excessive amount of chaff and short lengths of straw. Look in the grain tank for cracked kernels.

c. Finding the rack loss: The rack loss may be found as follows:

(1). Measure and mark with stakes the distance necessary to travel in cutting the test area.
(2). Catch all the material coming from the straw rack in a box or canvas.
(3). Collect the loose kernels and measure the loss in bushels per acre by one of the methods described.

Check the condition and the amount of straw as it comes from the rack to check the kind of job of combining you are doing. Has the straw been broken up by the cylinder?

d. Finding the shoe loss: On some combines this can be done by catching the material as it comes from the shoe and follow the same procedure used in finding the rack loss.

If it is not possible to catch the material as it comes from the shoe you will need to catch all the material coming from the rear of the combine. Collect the kernels which will represent both the rack and shoe loss. Subtract the rack loss from this and the remainder will be the shoe loss.

Examine the material in the tailings for excessive amounts of chaff and other debris. Look in the grain tank for dirt.

Student exercise: A field trip for the purpose of checking combine losses is recommended if combines are in operation at the time of this lesson. Otherwise, students should be encouraged to put this knowledge into practice at the first opportunity. The form "Record for Checking Losses" may be used to record the results of the tests.

RECORD FOR CHECKING COMBINE LOSSES

Name of farmer____________________________ Crop____________________

Condition of Crop (weedy, lodged, wet, etc.)____________________________

____

Width of cut ____ ft. x distance traveled ____ ft. = ____ft. sq. ft of test area.

Source of Loss	When kernels are counted		When kernels are measured	Loss in Bu. / A.
	Total No. Kernels	Kernels per sq. ft.	Cubic inches of Kernels	
1				
2				
3				
4				
5				
6				
7				

Observations:

Condition of straw as it leaves the rack:____________________________

____

Amount of chaff and other debris in tailings:__________________________

____

Are unthreshed heads going over the chaffer extension?____________________

____

Condition of threshed grain in the tank (damaged kernels or extensive dirt):

____

C. HOW COMBINE LOSSES MAY BE REDUCED.

What information did your combine test give to you? If the grain loss was low there may be no need to make adjustments in the machine. However, if the grain loss was high the results of your test will help you in deciding on the adjustments you should make.

Refer to your record of combine losses as you study this section on combine adjustments. Tests conducted by agricultural engineers show that adjustments should be made in the following order.[1]

1. Machine speed. Check the machine speed to see that the combine is operating at the recommended revolutions per minute (r.p.m.). Steady, smooth power is very important. Any changes in engine speed will change the speed of the separator. Uneven speed will cause loss of grain, poor threshing, and sometimes complete plugging of the machine. You should be sure your combine is operating at the proper machine speed before going into the field. The manufactures' operator's manual will give the basic speed of the machine. This may be given as beater shaft speed, engine speed at full throttle, separator shaft speed, etc. Some service men will call this the "key shaft" since the operating speed of the entire machine depends on this shaft operating at the recommended speed. Adjust the engine governor so that the basic speed is 3 to 5% above normal when the combine is running empty. A revolution counter, figure 30 should be used to measure power take off and straw rack speeds since most tachometers cannot be read accurately enough at low speeds.

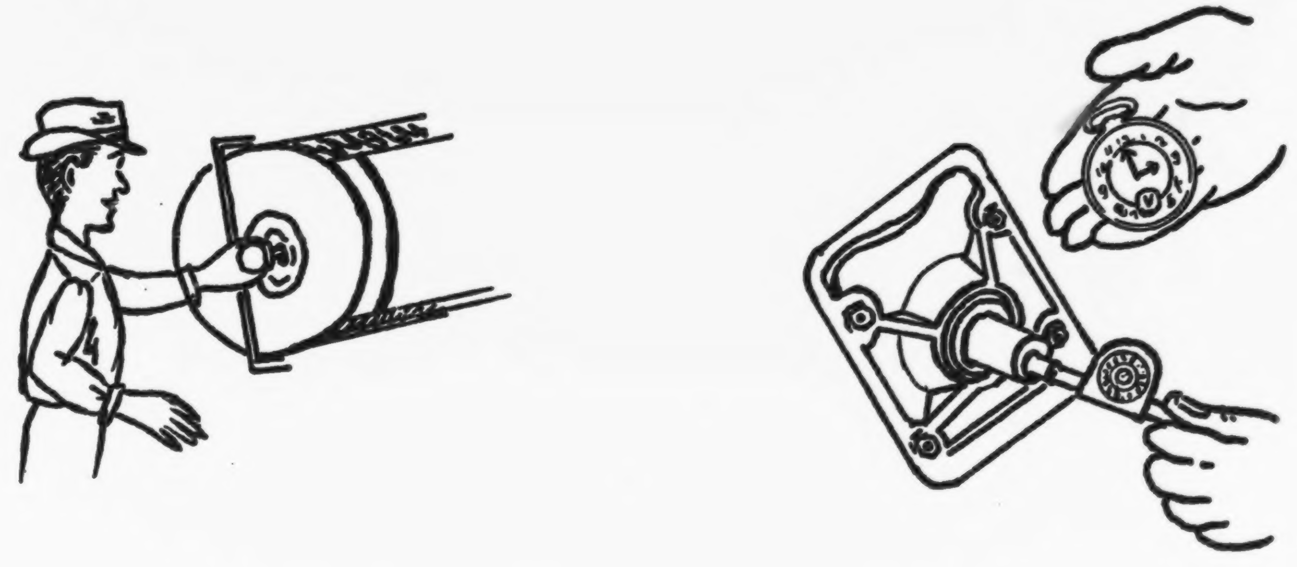

Figure 30. Check the machine speed by using a speed indicator on the "key" shaft.

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[1] S. G. Huber, Harvesting With Combines, The Ohio State University.

Student exercise: Check the operating speed of the combine you are working on in the shop.

Speed adjustments on the combine. Some parts of the combine are driven by belts running on pulleys or adjustable sheaves while other parts are run by chains and sprockets. Sometimes it is necessary to change the operating speed of a part such as the reel or the cylinder. This can be done as follows:

a. Pulleys. Power is supplied by one of the pulleys called the driver. This power is then transmitted by means of a belt to another pulley called the driven. Figure 33.

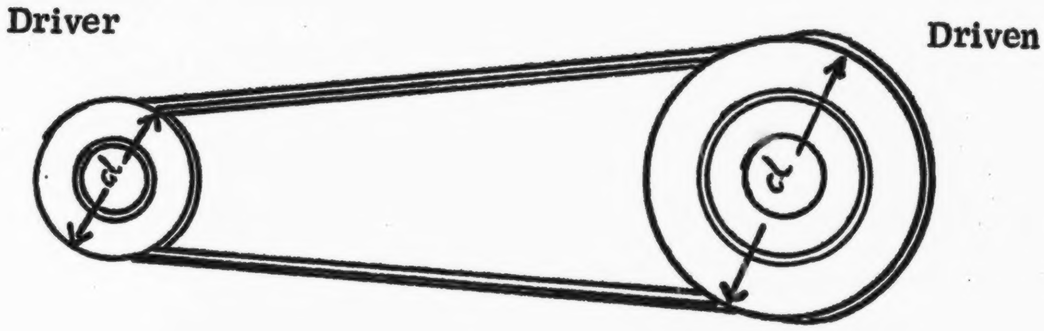


Figure 33. Pulley Speeds

If the driven pulley is to operate at the proper speed or r.p.m. (revolutions per minute) there must be a proper relationship between the size of the driver and the driven. The r.p.m. of the driver will usually not change because its power is supplied by the combine or tractor motor which should be run at full throttle all the time. This means that the speed of the driven can be changed by changing the size of one or both of the pulleys. The formula for this relationship is as follows:

Speed is measured by r.p.m.
Size of pulley is measured by diameter or d.
d of driver x r.p.m. driver = d of driven x r.p.m. of driven.

Example 1: If the driver pulley is 5 inches in diameter and is operating at 100 r.p.m., what will be the r.p.m of a 10 inch diameter driven pulley?

5" driver x 100 r.p.m. driver = 10" driven x X r.p.m. driven

500 = 10X

X = 50 r.p.m. of driven

Example 2. If the driven pulley is 4 inches in diameter and operating at 500 r.p.m., what would the diameter of the driven pulley be to operate at 800 r.p.m?

$$4'' \times 500 \text{ r.p.m.} = X \times 800 \text{ r.p.m.}$$

$$800X = 2000$$

$$X = 2.5'' \text{ diameter}$$

b. Sprockets. When sprockets and chain are used to transmit power from the driver to the driven the same principles of proportion are used except the size of the sprockets is measured by the number of teeth instead of using the diameter as with pulleys.

Example 3. If a driver sprocket has 5 teeth and is operating at 100 r.p.m. what will be the r.p.m. of a 10 tooth driven sprocket?

$$5 \text{ teeth} \times 100 \text{ r.p.m.} = 10 \text{ teeth} \times X \text{ r.p.m.}$$

$$500 = 10X$$

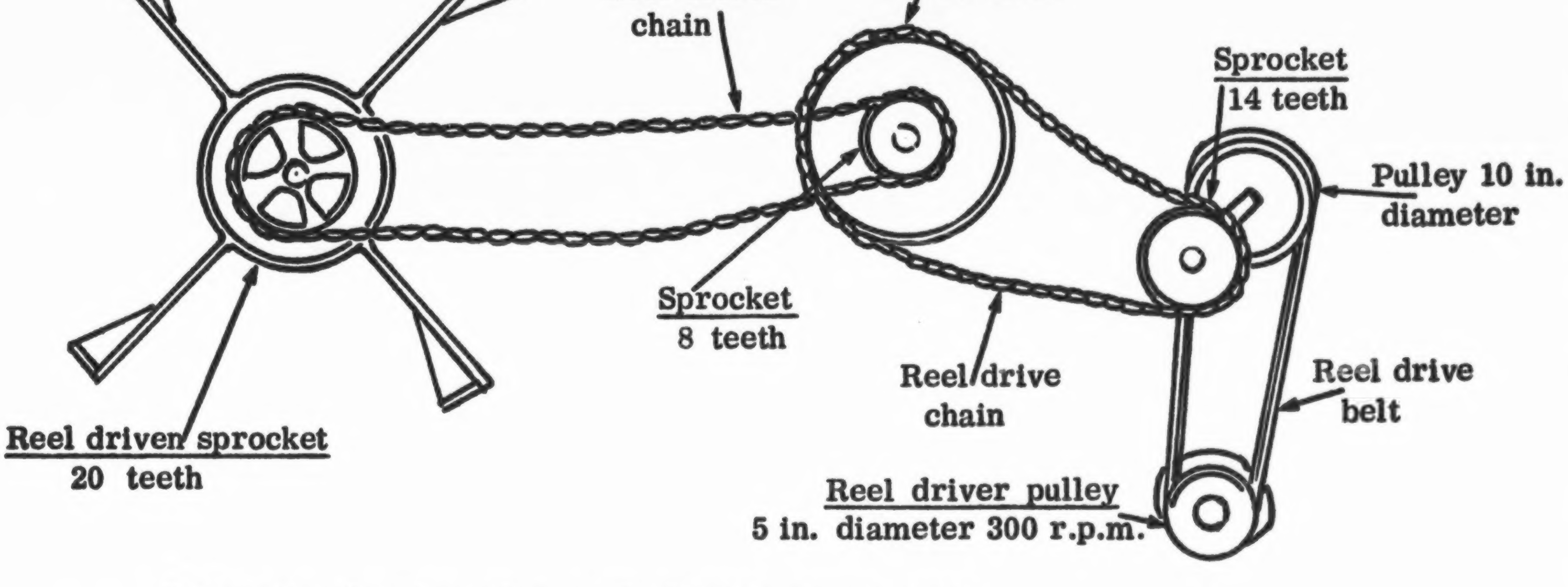
$$X = 50 \text{ r.p.m. of driven}$$

Notice that the answer is the same as in the first example with the pulleys since the proportions were the same.

Problem 1. If the sheave that drives the cleaning fan is 5 inches in diameter and operates at 750 r.p.m., what would the diameter of the driven sheave need to be to operate the fan at 900 r.p.m.? (Figure to the nearest tenth of an inch.)

Problem 2. If the sprocket that dirves the cylinder has 32 teeth and operates at 650 r.p.m. and the cylinder driven sprocket has 19 teeth, what will te the speed of the cylinder in r.p.m.? (Figure to the nearest whole number.)

Problem 3. In the illustration below at what r.p.m. is the reel traveling if the driver pulley is 5 inches in diameter and running at 300 r.p.m.?


Reel
Reel driven chain
Sprocket 28 teeth
Sprocket 14 teeth
Pulley 10 in. diameter
Sprocket 8 teeth
Reel drive chain
Reel drive belt
Reel driven sprocket 20 teeth
Reel driver pulley 5 in. diameter 300 r.p.m.

Schematic drawing of a reel driving power train.

Turn to the operator's manual for the combine you are working on and fill in the following information.

Table 4. Recommended Machine Operating Speeds.

Make and model of machine. ____

Part of combine to be checked for recommended speed.	recommended speed (r.p.m.)

2. Adjust the cylinder concave clearance and the cylinder speed. The cylinder loss is usually the lowest, but the cylinder - concave clearance and cylinder speed adjustments have a great affect on the rack and shoe losses in the combine. Poor adjustments in the threshing area will show up as follows:

Too little threshing action.	(1) Unthreshed heads.
Too much threshing action.	(1) Chopped up straw on the rack. (2) Excessive tailings. (3) Cracked grain.

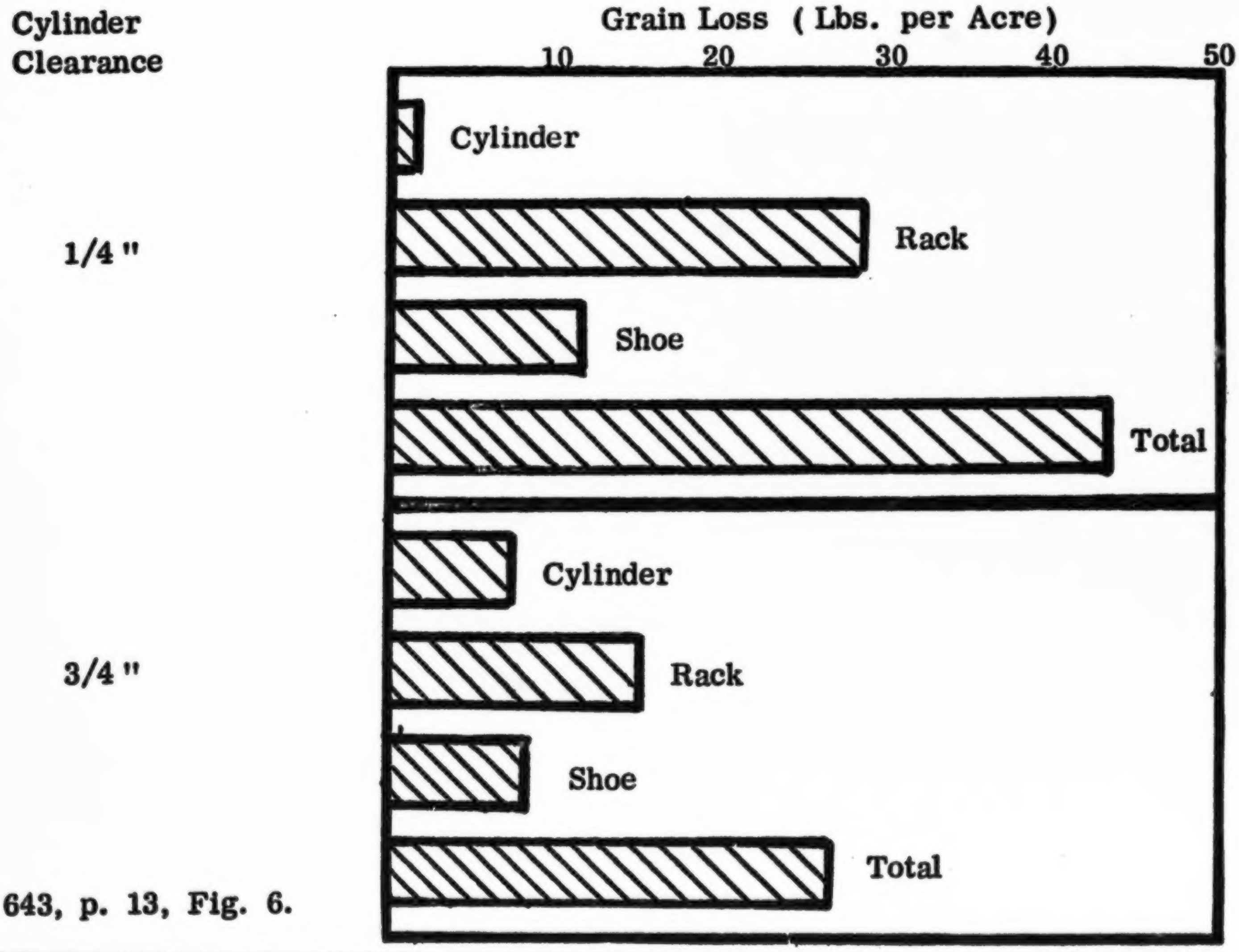
The threshing action may be changed as follows:

To increase—Increase the cylinder speed. Decrease the concave - cylinder clearance.

To decrease—Decrease the cylinder speed. Increase the concave - cylinder clearance.

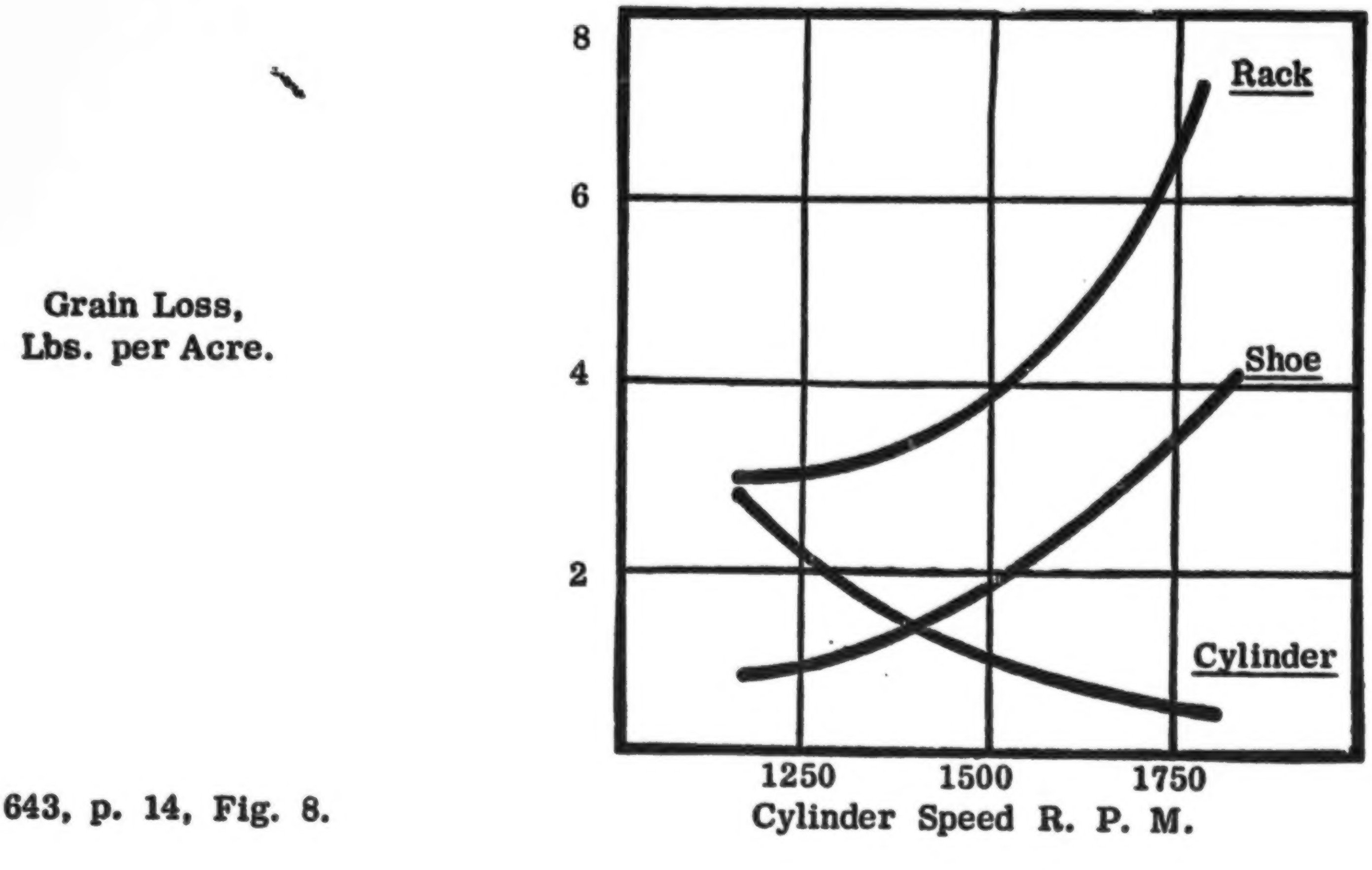
The most effecient job of separating and cleaning will be done by operating the machine with the least amount of threshing action required to remove the most of the kernels from the head. Over threshing breaks up the straw and causes the rack and shoe to be over loaded. Under threshing lets the heads go by unthreshed.

Figure 31. Small Cylinder Concave Clearance Reduces Cylinder Loss but Increases Total Loss.



OAES 643, p. 13, Fig. 6.

Figure 32. As Cylinder Speed Increases Cylinder Loss Decreases, but Rack and Shoe Losses Increase.



OAES 643, p. 14, Fig. 8.

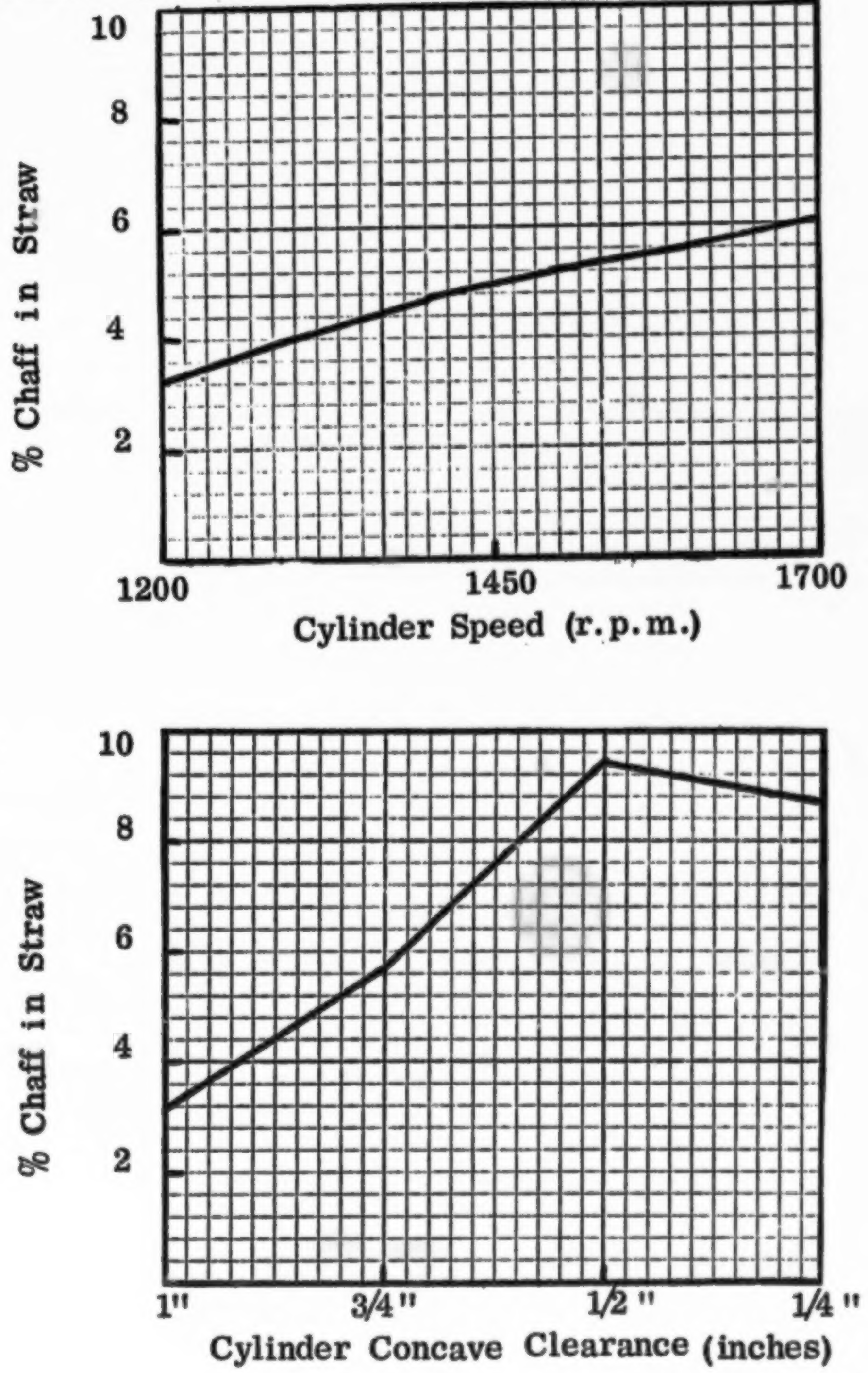
Figure 31 shows that a small cylinder clearance reduced the cylinder loss but increased the total loss. Increasing the cylinder clearance increased the cylinder loss slightly but decreased the rack and shoe loss making the total loss much less.

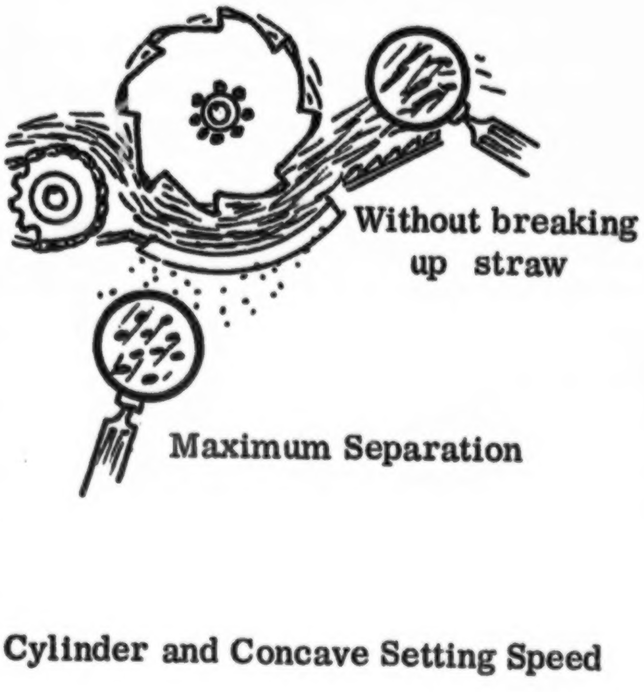
Figure 32 shows that high cylinder speeds reduce cylinder losses but increase rack and shoe losses. Decreasing the cylinder speed increased the cylinder loss slightly but reduced the rack and shoe losses greatly making the total loss less.

Many things will influence the proper cylinder speed and cylinder-concave clearance that will bring about the most efficient job of combining possible for your conditions. Increasing the cylinder speed seems to cause less over threshing than does decreasing the cylinder-concave spacing. Figure 34.

Figure 34.

The percentage of chaff in the straw increases as the cylinder speed increases and as the cylinder concave clearance





The first step is to study the operator's manual to determine the settings recommended for the crop you are harvesting.

Student exercise: Find this information for your combine and fill in table 5.

Table 5. Manufacturers recommendations for cylinder speed and cylinder - concave clearance.

Crop being harvested____

Condition of crop____

Adjustment	Recommendations	How adjustment is made
Cylinder speed (r.p.m.)		
Cylinder - concave clearance. (inches)		

These adjustments will be satisfactory for a trial run, but as one manufacturer says in his operator's manual, " The correct cylinder adjustment for any kind of grain must be determined by trial." [1]

The cylinder speed recommendations for threshing some crops will be given as peripheral speed which is the feet per minute a given point on the circumference of the cylinder would travel (sometimes called surface feet per min.)

Example: If the recommended peripheral speed of the cylinder is 4500 ft. per minute and the diameter of the cylinder is 24 inches, at what r.p.m. should the cylinder run to maintain this peripheral speed?

You will first need to know the circumference of the cylinder to know how far a point on the cylinder must travel to complete one revolution. The number of times the circumference is contained in the recommended peripheral speed will give the required r.p.m. of the cylinder.

$$\text{Circumference} = \text{diameter} \times \text{pi} \ (\pi)$$

$$C = 2 \text{ ft.} \times 3.1416$$

$$C = 6.2832 \text{ ft.}$$

$$\frac{4500 \text{ ft.} / \text{min.}}{6.2832 \text{ ft.}} = 716 \text{ r.p.m.}$$

Problem: You are preparing to combine alfalfa seed. You want the cylinder to have a peripheral speed of 5000 ft. per minute. Your cylinder is 18" in diameter. At what r.p.m. should it operate to give you the desired peripheral speed?

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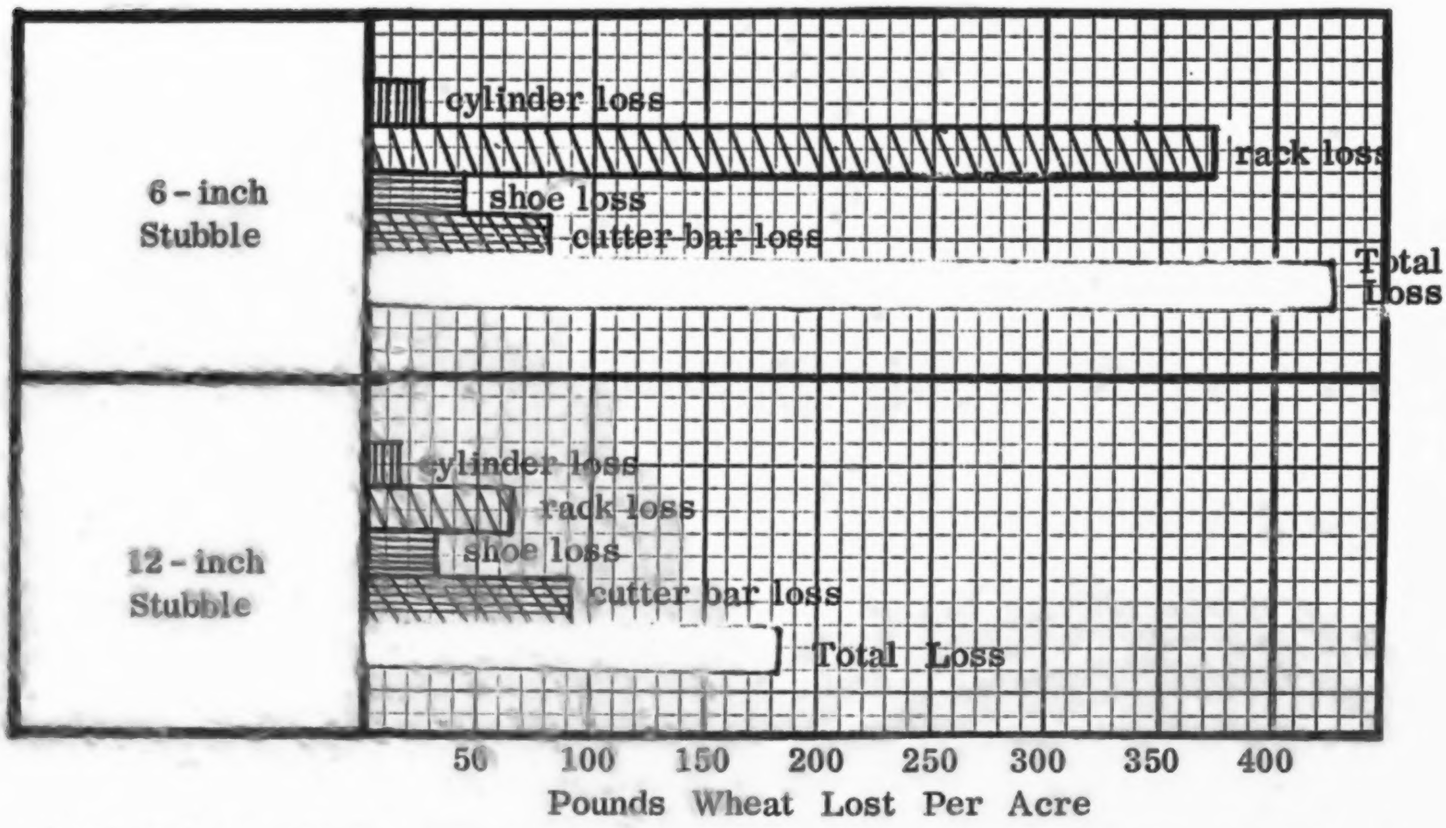
[1] Operator's Manual, IHC COMBINE.

3. Adjust the cutter bar height. The cutter bar area usually has highest loss of the four areas of the combine. The height of cut should not be lower than required to get all or most of the heads off the grain. Figure 35. Height of cut losses will show up as follows:

Too high: Heads or pods of grain will be left in the field.
Too low: Too much material will be run through the combine and will over load the rack causing this loss to increase more than it should. Figure 36.

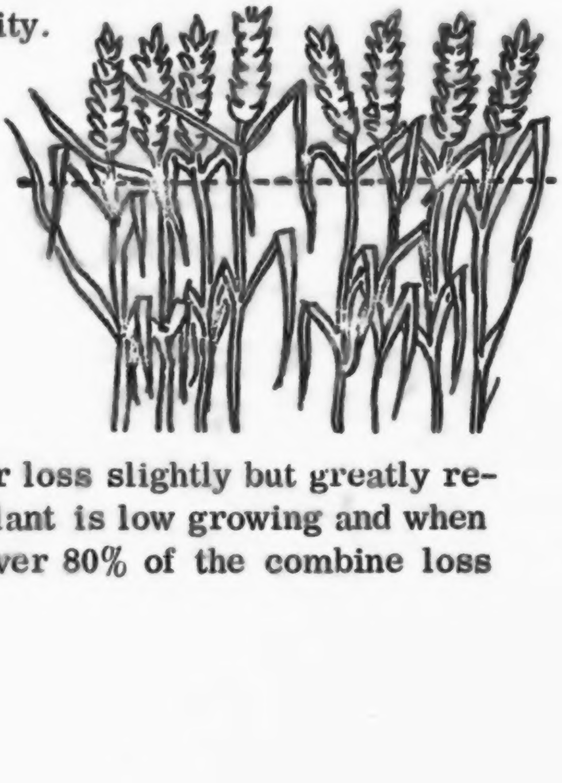
Figure 35. Increasing the height of cut decreases the total loss. (Wheat) Due to over loading the combine.*



*Harvesting With Combines, The Ohio State University.

Figure 36.

Cut just low enough to get all the heads.



Raising the height of cut increased the cutter bar loss slightly but greatly reduced the rack loss of the machine. The soybean plant is low growing and when ripe, the beans shatter easily. Because of this, over 80% of the combine loss takes place in the cutting and feeding area.

Student exercise: Study your operator's manual, your combine, and the condition of the crop being harvested to find the information for table 6.

Table 6. Recommendations for height of cut.

Crop being harvested____

Condition of crop____

Adjustment	Recommendations	How adjustment is made
Height of Cut		

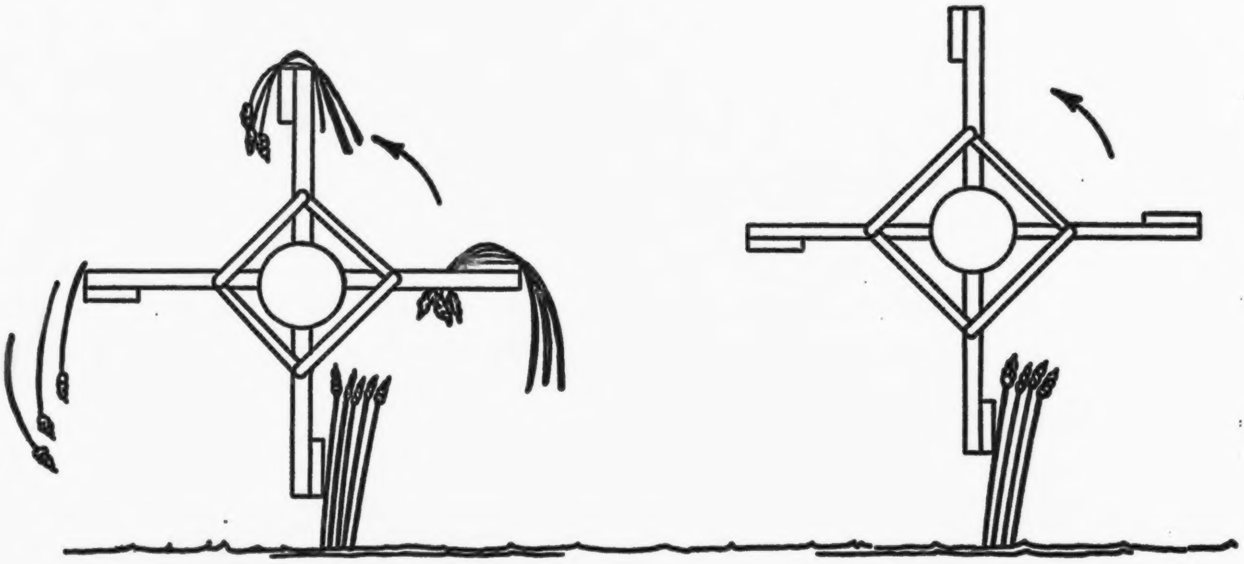
4. Adjustable reel. A poorly adjusted reel will cause some of the loss in the cutter bar area of the combine. The reel may be adjusted for speed, height, and forward or rearward. Reel losses will show up as follows:

Reel too fast:	(1) The bats strike the grain with such force that grain will be shattered and lost. (2) Grain carried over top of reel.
Reel too slow:	(1) The cut grain may fall to the ground and be lost. (2) The cut grain may fall on the cutter bar causing the grain to be cut up or the knife to choke. (3) Down, tangled grain or short straw may not be moved onto the platform.
Reel too low:	(1) The grain may tend to wrap around the bats.
Reel too high:	(1) The grain will not be moved onto the platform.
Reel too far forward:	(1) The grain will not be moved onto the platform.
Reel too far back:	(1) The grain may not be fed uniformly into the combine.

The adjustment of the reel will depend on the condition and the nature of the crop being harvested. Manufacturers give the following recommendations for the reel setting:

a. Reel speed: The speed of the reel depends on the condition of the crop. It should be as high as possible without shattering the grain or throwing grain from the feeder. The reel should travel slightly faster than the forward travel of the combine.

b. Reel height: Usually the reel should be set so the bats, when in their lowest position, will strike just below the lowest heads of grain. Figure 37. This will keep the bats from beating the grain from the heads.



IF THE GRAIN TENDS TO WRAP AROUND THE BATS............
.......RAISE THE REEL TO JUST BELOW THE LOWEST HEADS.

Figure 37. Reel Adjustment. (Courtesy J. I. Case Company.)

c. For different crop conditions:

(1) For medium and short crops, adjust the reel approximately four inches above the cutter bar and far enough forward so that the bats do not leave the grain until it is cut.

(2) For taller crops, set the reel back and raised so the bats run close to the top of the grain.

(3) For down crops, adjust the reel to a low and forward position with reel bats set flat.

Student exercise: Study your operator's manual and the condition of the crop to be harvested to find the information for table 7.

Table 7. Recommended Reel Adjustments

Crop being harvested______________________________

Condition of crop________________________________

Adjustment	Recommendations	How adjustment is made
Reel Speed (r.p.m.)		
Reel Height		
Position forward or rearward		

5. Speed of forward travel: Figure 38. Driving too fast will overload the combine causing excessive rack loss.

Overloading the combine by driving too fast or setting the cutterbar too low is the most common cause of high rack loss. Figures 35 and 39 show the effects of overloading on machine losses. Although these charts were made from studies in combining wheat, the same principles apply to combining other crops. The only way to find out if the machine is overloaded is to measure rack loss. The straw rack usually overloads before other parts of the machine.

Overloading is one of the big problems in harvesting legume seed. A very low rate of travel is advisable.

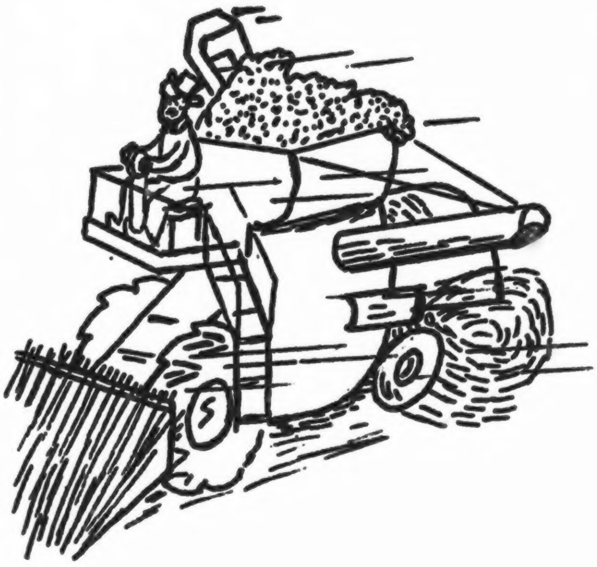
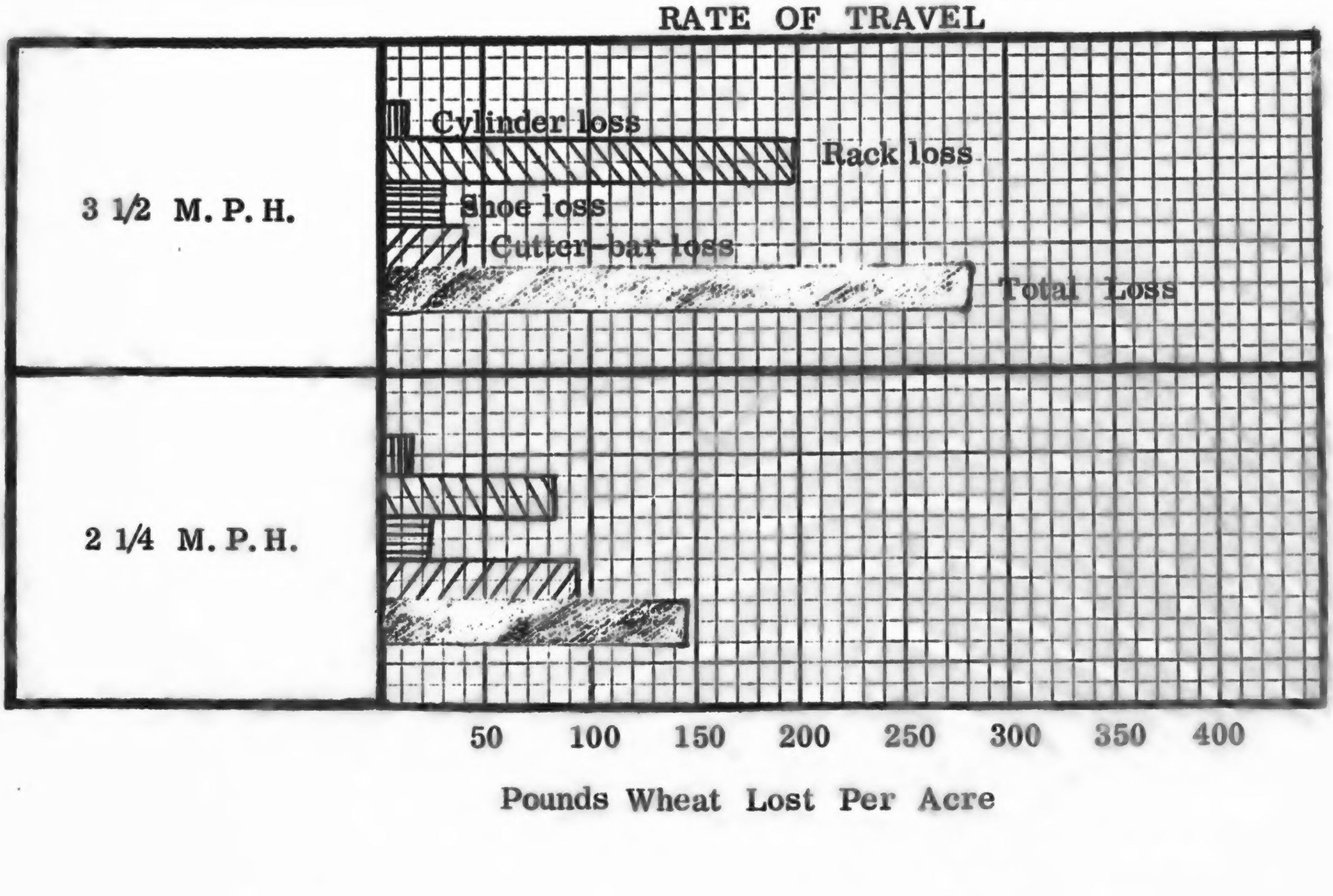


Figure 38. Fast driving overloads the combine.

Figure 39. Driving too fast increases total losses due to overloading the combine.



Ground speed should not be changed by using the throttle. The engine should always be run at full throttle to keep the machine speed up to recommended levels. (See section C. 1.) Forward travel speed should be adjusted by shifting transmission gears and, also, on self-propelled combines, by changing the selective ground speed drive adjustment.

Student exercise: Study your operator's manual, the condition of the crop to be harvested, and the kind of ground you have to cover to determine your recommended speed of forward travel. Place your recommendations in Table 8.

Table 8. Speed of Forward Travel

Recommended Speed m.p.h.	Transmission gear to use	Selective ground speed lever adjustives for self propelled machines

6. Adjust the cleaning sieves and fan blast.

Some of the losses in the cleaning area are caused by poor adjustments in other sections of the combine and can only be reduced by making the proper changes in these areas. These causes are as follows:

Overthreshing causing chopped up straw and excessive chaff which over loads the chaffer and sieve. (See section C-2.)

Overloading the combine by cutting lower than necessary to harvest the grain. (See section C-3.)

Overloading the combine by driving too fast for the condition of the crop. (See section C-5.)

Poor adjustments in the cleaning area of the combine will also cause grain loss. These adjustments and the operating loss or trouble they will cause are as follows:

a. Chaffer opening adjustment.

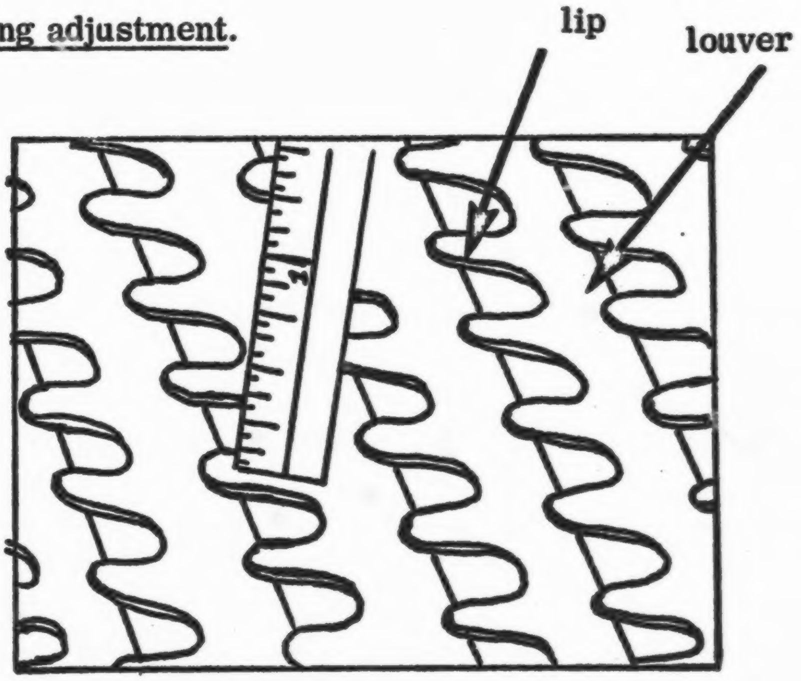


Figure 40

Chaffer Opening Adjustment

The lips may be raised or lowered to regulate the size of openings on the chaffer.

(1) Chaffer openings too large allowing too much chaff and other trash to fall through the chaffer onto the sieve.
(2) Chaffer openings too small allowing the grain to be carried over the chaffer in a blanket of material.

The chaffer openings should be large enough to allow the grain to work through the chaffer before it passes over two thirds of its length. At the same time chaff, weed stems, straw joints, and other coarse materials should be floated onto the chaffer extension.

b. Chaffer height adjustment. On some combines the rear of the chaffer can be raised causing the material to move up hill thus keeping it on the chaffer longer and increasing the cleaning action. When this is done the chaffer openings must be made smaller. This adjustment is used when light seeds, such as clover, are being harvested.

c. Chaffer extension opening adjustment.

(1) Chaffer extension openings too large, allowing too many weed stems, straw joints, and other coarse material to pass through into the tailings. This material is returned to the cylinder and will cause overloading in that area.

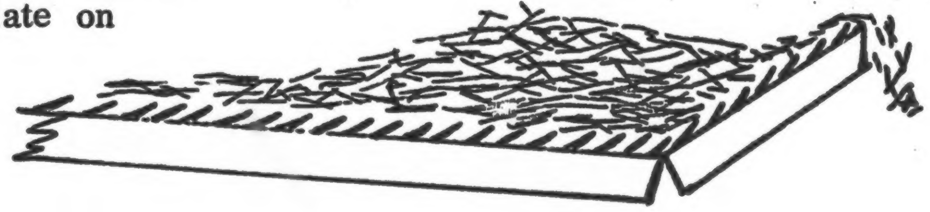
(2) Chaffer extension openings too small, allowing unthreshed portions of the heads to pass out of the combine.

The chaffer extension openings should be large enough to allow the unthreshed portions of the heads to pass through into the tailings trough to be returned to the cylinder for rethreshing. At the same time the coarse materials should be carried out of the machine.

d. Chaffer extension height adjustment.

(1) Chaffer extension adjusted too high causing choking at the rear of the chaffer sieve. Figure 41.

Figure 41. Chaffer extension too high causing material to accumulate on chaffer causing choking.



(2) Chaffer extension adjusted too low allowing light grain to be blown over.

The chaffer extension should be just high enough to prevent light grain from being blown over and low enough to prevent clogging at the rear of the chaffer.

e. The shoe sieve opening adjustment.

(1) Shoe sieve openings too large allowing an excessive amount of trash to fall into the clean grain auger. This trash will show up in the grain tank.

(2) Shoe sieve openings too small causing the grain to be carried over the sieve into the tailings auger where it is returned to the cylinder. This overloads the cylinder and increases the amount of damaged kernels.

The shoe sieve openings should be small enough to allow only threshed grain to pass through into the grain auger. White caps, straw joints, and pieces of unthreshed heads should be floated over into the tailings auger.

f. Shoe sieve height adjustment. On some combines the rear of the sieve can be raised causing the material on the sieve to be retarded, thus keeping the material on the sieve longer and giving the grain a better chance to pass through to the clean grain auger.

g. Special shoe sieve. Round or elongated hole sieves are available for cleaning special crops. See your operator's manual for recommendations.

h. The cleaning fan. The air blast from the fan is directed upward and to the rear through the sieves agitating or floating the material on the chaffer to aid in separation of the seed as the material moves to the rear. The air blast also blows out most of the light, chaffy material as the seeds fall through the openings of the chaffer sieve and then through the smaller openings of the shoe sieve.

i. Force of cleaning fan air blast. The force of the cleaning fan air blast may be controlled by regulating the speed of the fan or by controlling the amount of air coming into the fan.

(1) Fan speed.

(a) If the fan speed is too high the force of the air blast will blow the grain over the sieves.
(b) If the fan speed is too low the material will form a mat on the sieves keeping the grain from falling through.

(2) Fan wind regulators control the amount of air that enters the fan which in turn helps to regulate the strength of the air blast.

(a) Opening the wind regulators too much will increase the air blast and blow the grain over as in (a) above.
(b) Closing the wind regulators too much will decrease the air blast allowing the material to form a mat on the sieves keeping the grain from falling through as in (b) above.

The force of the cleaning fan air blast needed to do a satisfactory job of cleaning is determined by the size and weight of the seed, plus the amount of chaff going over the sieves. In general, the smaller the seed the less the force of the air blast should be and the larger the seed the greater the force of the air blast should be. Dirty crops usually require a stronger air blast than do clean crops. Figure 42.

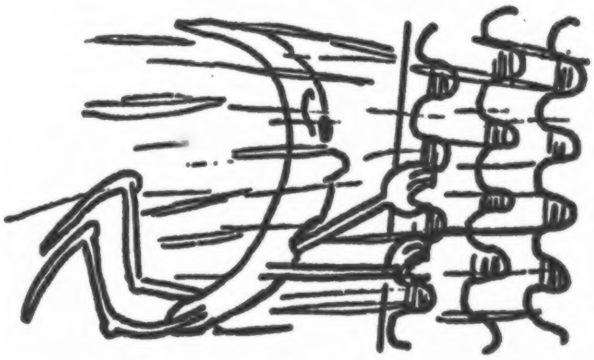


Figure 42

Use Proper Amount of Blast

j. Direction of the air blast. The direction of the air blast is controlled by a fan wind deflector, wind boards, or air valves as they may be called.

(1) Air blast directed too far back on sieves will cause grain to be carried over with the chaff.

The deflector must be set to suit crop conditions. If grain is being carried over with the chaff, after the chaffer and shoe sieve are properly adjusted, set the deflector in a position to direct the air upward to the front of the chaffer and shoe sieve.

k. Tailboard. The tailboard can be raised and lowered as necessary to prevent unthreshed material from being carried out of the rear of the separator while still allowing for the chaff to be blown out.

Threshing SERVICE HINTS CORRECTIONS PROBLEMS	adjust auger fingers	adjust concave or cylinder	adjust cylinder cut off bar	adjust cylinder speed	adjust drive belt (flat)	adjust elevator chains	adjust fan mill speed	adjust feeder chain	adjust reel speed	check "key" shaft or drive	adjust sieves	adjust slip clutches	adjust table auger speed	adjust table auger	adjust upper sieve extension	adjust rack speed	adjust rack drive belt	adjust windboards	check curtain in body	check for plugged concave	check space between walkers	check front beater speed	close shutters on fan mill	crop too green	ground speed too fast	install filler plates	knife not centering	knife sections need replacing	ledger plates dull	machine running too slow			
back feeding		X	X	X	X			X		X						X	X					X											
cracked grain		X		X		X																											
cylinder plugging		X	X	X																													
excess chaff				X			X			X	X																						
excess gleanings		X		X			X			X	X				X			X															
elevator to cylinder plugging			X					X				X	X																				
elevators stopping						X						X												X									
grain bunching in front of auger	X												X	X										X									
loss of grain over shoe		X		X	X		X			X	X																						
loss of grass seed over shoe		X		X	X		X			X	X												X		X	X							
loss from table	X				X				X				X																				
loss over walkers		X		X												X			X	X	X												
overthreshing		X		X																													
ragged stubble																									X		X	X	X	X			
straw gathers on windscreen	X								X				X																				
straw spreader spreads unevenly										X							X																
unthreshed heads		X		X																						X							

Figure 43. Threshing Problems Service Hints.
Courtesy, Massey - Ferguson Limited.

Courtesy, Massey - Ferguson Limited.

Mechanical SERVICE HINTS CORRECTIONS PROBLEMS		adjust table balance springs	adjust table lift arms	adjust and lubricate drag links	adjust unloader belt	adjust belt clearance at motor pulley	belt not adjusted at transmission pulleys	clean radiator screen and core	check oil level in hydraulic pump	check pump drive belt for non slippage	control arm on speed valve not adjusted	check speed yoke for straigntness	check for hydraulic oil leaks	check timing at distributor	check rear tire pressure	check to see that shoe does not hit body	damaged hydraulic lines or fittings	dealer service required	fill fuel tank	fill radiator	gears damaged in vari speed valve	no harm to pump (characteristic)	"O" ring on speed cylinder damaged	recharge battery	refer to operator's manual	remove stalks from sieves	restrictor valve in speed cylinder	spring can on transmission pulley weak	tighten fan belt	turn on ignition switch	turn on fuel at tank	
belt slipping on traction drive						X	X																					X				
combine not coming to a complete stop						X					X																					
cylinder chain adjustment																									X							
engine overheating								X						X						X									X			
engine will not start														X					X					X						X	X	
cears clash when selecting gears						X					X																					
grain unloading belt slipping					X																											
ground speed uneven									X			X									X		X									
knocking in pump (Bendix)																						X										
machine hard to steer				X											X										X							
machine hard to steer (hydraulic)				X					X	X			X		X		X								X							
sieves being damaged																X									X	X						
table will not lift		X	X						X	X			X					X														
table will not lower		X	X						X	X								X														
vari-speed will not move machine									X	X	X		X					X			X						X					

Figure 44. Mechanical Problems Service Hints.

Student exercise: The condition of the crop being harvested will determine the adjustments needed in the cleaning area of the combine. Study your operator's manual and the combine in the shop to determine the adjustments that are recommended for this area of the combine. Place the information in table 9.

Table 9. Recommended adjustments in the cleaning area of the combine. (Not all of the adjustments are on each make of the combine.)

Crop being harvested______________________________________

Condition of crop______________________________________

Adjustment	Recommendations	How adjustment is made
Chaffer Opening		
Chaffer Height		
Chaffer Extension Opening		
Chaffer Extension Height		
Shoe Sieve Height		
Special Shoe Sieves		
Fan Speed		
Fan Wind Regulator		
Fan Wind Deflector		
Tailboard		

7. Cutter bar adjustment. The cutter bar provides the support for the guards and sickle. The cutting is accomplished by the shearing action caused as the knife section slides over the guard. To cut properly, the knife must run smoothly in the cutter bar and every knife section must rest on the guard in position to make a shear cut. This means the guards, wearing plates, and knife clips must be in good condition and properly set. (Figure 45.) If these parts become loose or worn, the knife will chew and tear the crop instead of cutting it. This will also cause excessive shattering of ripe crops.

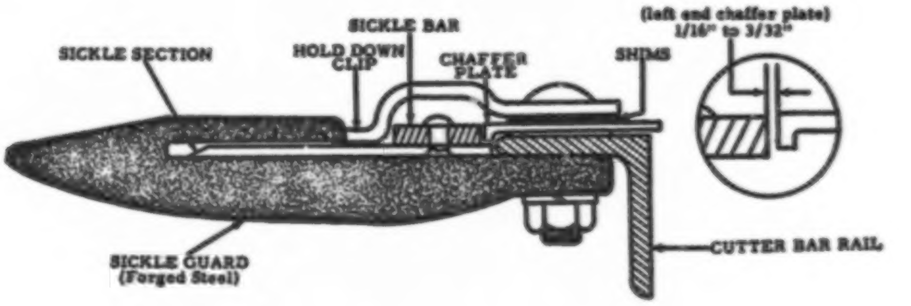

SICKLE SECTION
HOLD DOWN CLIP
SICKLE BAR
CHAFFER PLATE
SHIMS
(left end chaffer plate)
1/16" to 3/32"
SICKLE GUARD
(Forged Steel)
CUTTER BAR RAIL

Figure 45. Cutter Bar Adjustment. (Courtesy, J. I. Case Company)

a. Guard alignment. Set each guard up or down as necessary to obtain a shear cut between the knife section and the guard. Tighten the bolt as each guard is aligned. (Figures 46 and 47.)

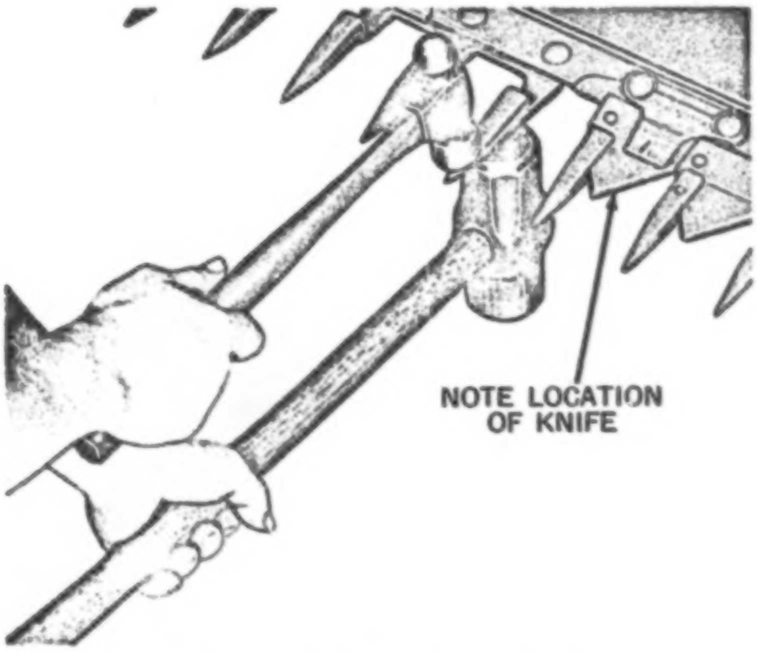

NOTE LOCATION
OF KNIFE

Figure 46. Setting Guard Down.
(Courtesy, John Deere)

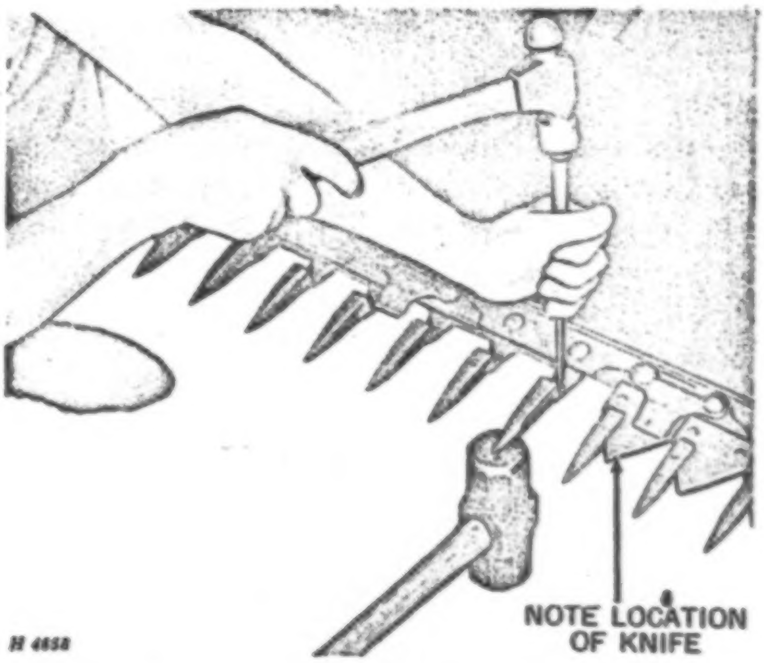

H 4658
NOTE LOCATION
OF KNIFE

Figure 47. Setting Guard Up.
(Courtesy, John Deere)

b. Knife clips. The knife clips must keep the knife sections from lifting off guards and permit the knife to slide without binding. Set the knife clips after guards are aligned. Never bend a knife clip down when the knife is under it. See figures 48 and 49 for instructions. Some models use shims under the knife clips so they may be adjusted up or down by adding or removing shims. (Fig. 48)

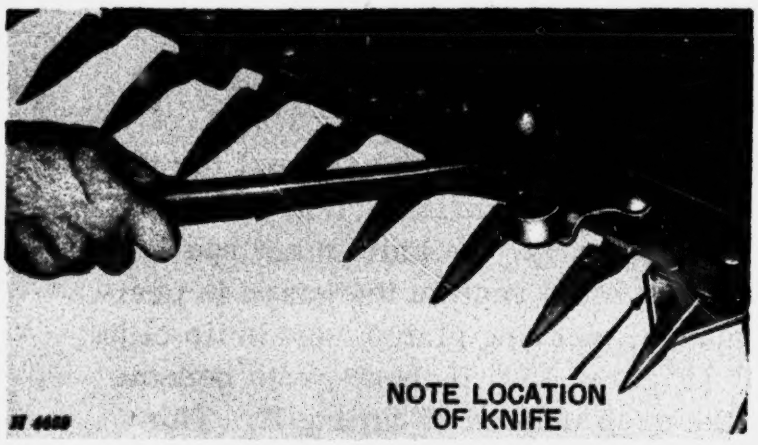


Figure 48. Setting Knife Clip Down
(Courtesy, John Deere)

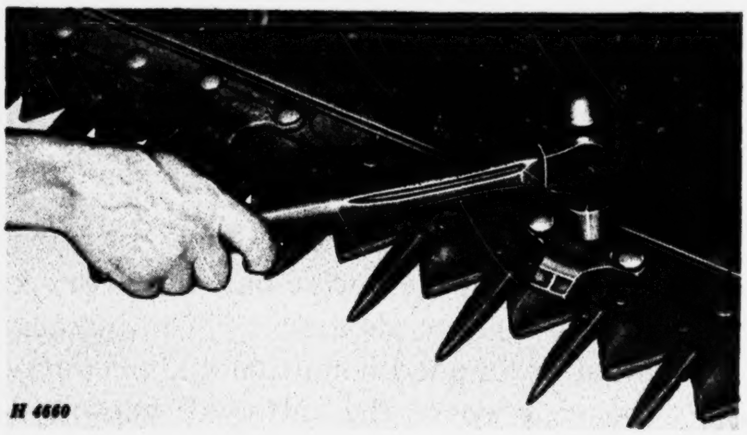


Figure 49. Setting Knife Clip Up
(Courtesy, John Deere)

c. Wearing plates. Wearing plates are located along the entire length of the knife back and may be moved back and forth to take care of wear on the knife back. The turned down edges of the wearing plates must line up with each other to give the knife back a straight bearing edge along its entire length.

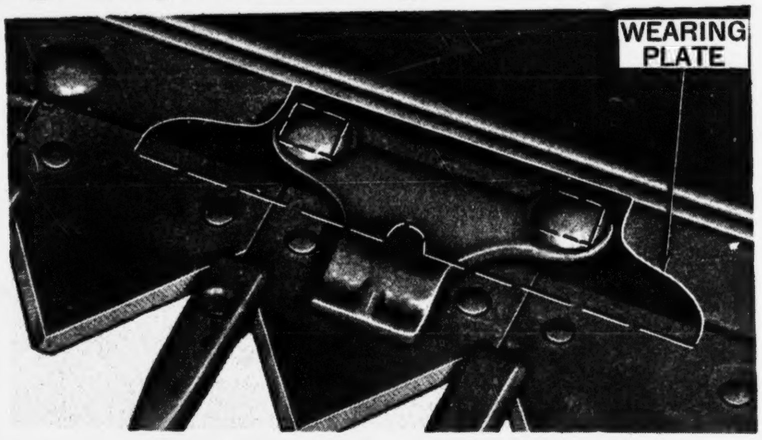


Figure 50

Wearing Plate Adjustment

d. Sickle register. With each revolution of the pitman sickle drive, the sickel moves to the left and to the right. The sickle is in proper register when the sections center on the guards with the sickle at the end of its strike. Figure 51, proper register, provides good shearing action by the sickle section. Figure 52 shows the sickle sections out of register.

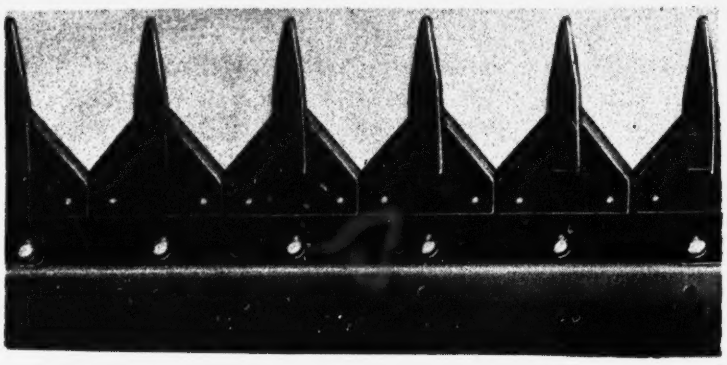


Figure 51. Proper Sickle Register
(Courtesy, John Deere)

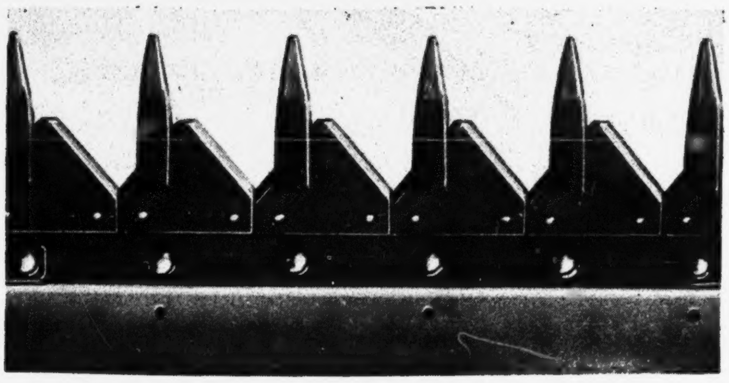


Figure 52. Improper Sickle Register
(Courtesy, John Deere)

The sickle register is usually adjusted by lengthening or shortening the pitman arm. (Figure 53.) Check your operaotrs manual for the instructions on your combine.

e. The sickle may develop an excessive amount of vertical or lateral play caused by wear and loose parts. Follow your operator's manual in making the adjustments to correct this condition. The sickle may also develop back lash because of wear in the sickle drive mechanism. Your operator's manual will tell you how to correct this. After making the above adjustments be sure the sickle moves freely throughout its normal stroke. If any of the parts are adjusted too tightly heating and excessive wear will take place.

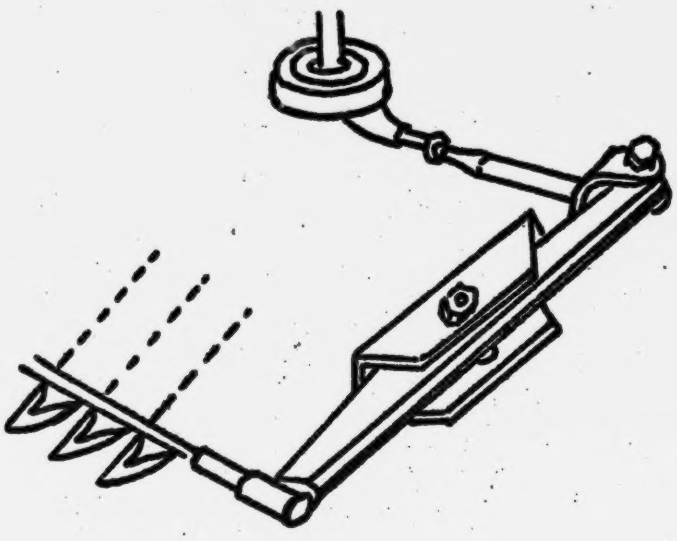


Figure 53. Sickle drive assembly.

8. Factors affecting combine efficiency. Adjustments must be made frequantly to meet changing crop conditions. Harvesting characteristics of grain will change from hour to hour, day to day, and field to field.

a. Varieties. Different varieties of grain may require considerable change in machine adjustment. Always check machine adjustment when starting to harvest a different variety.

b. Effect of weeds. Weeds, or other green material, increase losses in combining (Figure 54) and also increase the moisture content of the harvested grain. The losses increase because of the heavy mat of green material which forms on the straw rack, chaffer and sieves. Some things that may be done to reduce losses and the amount of moisture added to the grain are as follows:

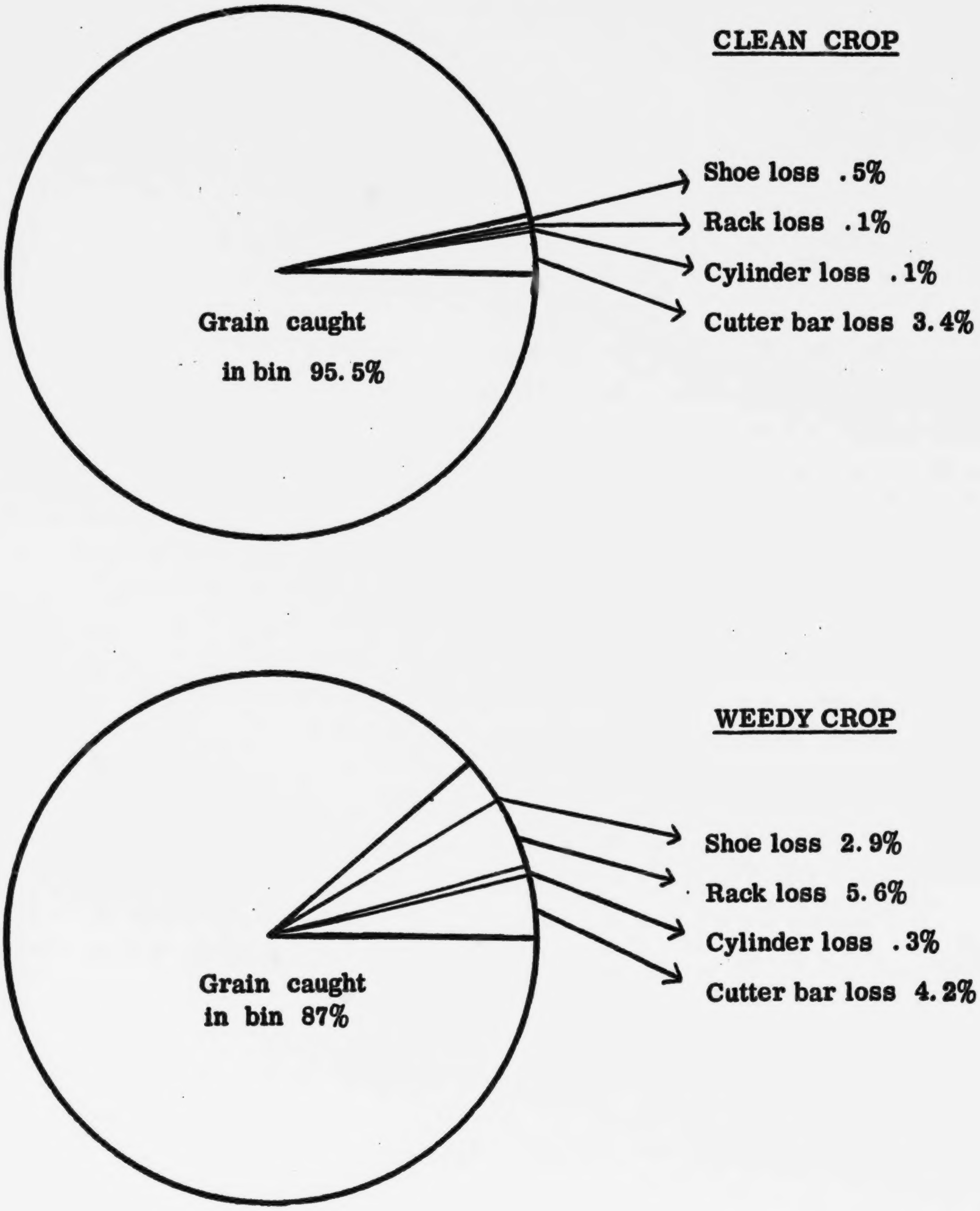
(1) Reduce the amount of green material taken into the machine by cutting around patches of weeds or raising the cutter bar if the green material is not as tall as the crop.

(2) If green material must be taken into the machine the following steps may be taken:

First, reduce the rate of travel or take a narrower cut.
Second, increase the cylinder-concave clearance so the green material is broken up as little as possible.
Third, change the direction of the fan blast forward so that a strong air blast is present where the grain leaves the grain pan and passes onto the chaffer.

(3) Windrowing may be used to avoid taking green material into the machine. The crop should be cut and windrowed about a week to ten days before a clean crop would be combined. Two or three good drying days are required for the windrow to reach threshing condition. The windrow should be loose and fluffy and resting on stubble.

Figure 54. WEEDS INCREASE COMBINE LOSS



(OAES 643, pg. 19)

9. Stone ejector: Under some harvesting conditions it is desirable to operate the cutter bar or corn head, as the case may be, as close to the ground as possible. If stones or other foreign objects are on the surface of the ground they may be picked up and fed into the cylinder causing a great amount of damage to this part of the combine. To safeguard against this happening some combines are equipped with a stone rejector which permits stones to be thrown out before they have the opportunity to damage the cylinder and concave. Figure 55 shows the safety concave door on the Gleaner combine.

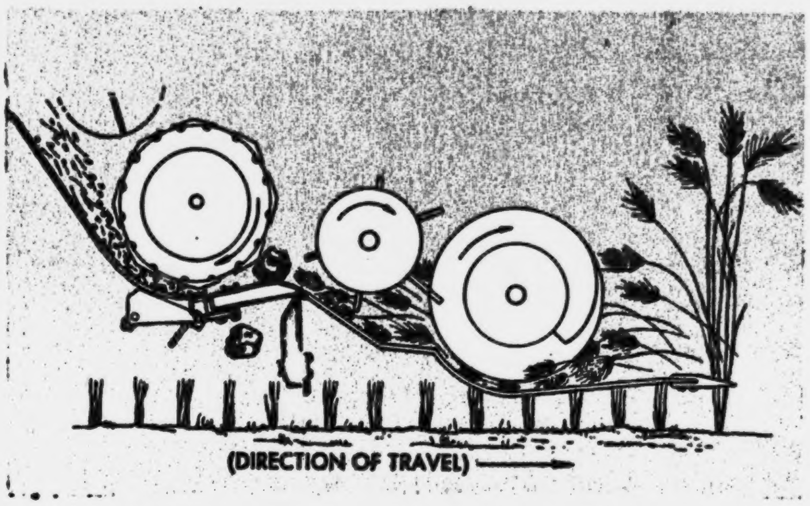


Figure 55. Stone ejector: If a stone or other foreign object enters, the concave door opens to eject it. Merely relatch door and continue combining.

(Courtesy Allis-Chalmers Mfg. Co.)

10. Automatic height of cut controls: Under certain harvesting conditions it is desirable to operate the cutter bar as close to the ground as possible to reduce cutter bar losses. It is difficult for the operator to gauge the height of the cutter bar above the ground. Devices which maintain a pre-set height have resulted in less operator fatigue and more efficient harvesting. (Figure 56)

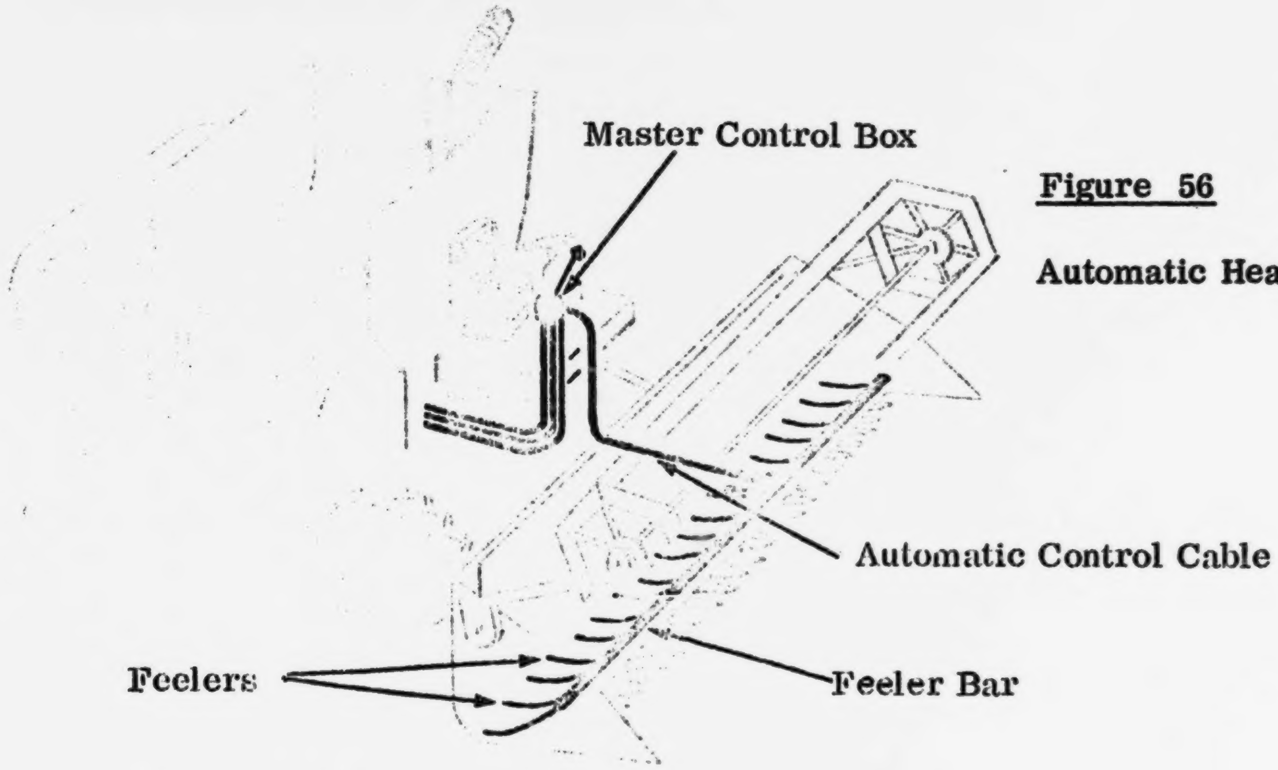


Figure 56

Automatic Header Control

(Courtesy Roper Wright Co., Inc.)

The automatic height of cut controls are of two types:

a. Hydraulic control: (Figure 56) A feeler bar is suspended from the platform on several hangers. The feeler bar is free to move up and down and follows the contour of the ground. When the feelers drop into a low spot they cause the hydraulic control to lower the cutter bar and likewise cause the cutter bar to be raised when the feelers strike a high spot. (For additional information contact M & W Gear Company, Gibson City, Illinois or Roper-Wright Mfg. Company, Inc., Box 343, Elwood, Indiana.)

b. Mechanical spring float has an adjustable plate under the full width of the cutter bar. The device is counterbalanced with springs and allows the cutter bar to float at a uniform height above the surface of the ground. (Available for John Deere Combines)

11. Conclusion: Before the operator makes adjustments on his combine to reduce harvesting losses he should first determine the causes of these losses by means of field checks and observations of the combine while it is working. Adjustments should then be made in the order recommended in this manual. A knowledge of the functional design of the combine and the principles of operation will help him in determining the parts that need adjusting and what the adjustment should be. This knowledge may be obtained by a combination of experience in operating the combine and in studying the operator's manual and other materials on combines.

Experience shows that operators will often make adjustments that do not correct the trouble and move on to make an adjustment in another area of the combine without returning the first adjustment to its original setting. If this procedure is continued the entire combine will soon be completely out of adjustment. Thus, if an adjustment is made that does not correct the trouble the setting should be returned to the position recommended by the manufacturer before making another change.

The service hints given in figures 43 and 44 should serve as a guide in adjusting and maintaining the combine. The charts are adopted from the Massey-Ferguson "Combine Packet Manual."

D. HARVESTING RECOMMENDATIONS BY CROPS

Each crop will present different problems to the combine operator. The combine manufacturer's operator's manual gives recommended adjustments, attachments, and operating suggestions for each of the crops the machine is designed to harvest. These recommended adjustments are starting points for the operator. The procedure outlined previously should be followed to get the best possible job of combining.

Our Experiment Stations have conducted tests to determine the most favorable condition for harvesting some of our main crops. This information can help us in determining the best time to combine from the standpoint of crop quality and harvesting losses.

1. Wheat harvesting recommendations:[1] The usual recommendations for combine harvesting of wheat is not to start the machine until the moisture level is below 14 per cent. This permits safe storage of the grain or selling without dockage due to excess moisture.

Wheat matures at about 30 per cent moisture. With each day of delay in combining after maturity there is about 12 pounds per acre less grain to harvest due to shattering and other losses.

It is not recommended that wheat be combined when it contains between 20 and 30 per cent moisture for the following reasons:

a. The kernels are badly damaged by the cylinder action.
b. The grain will not keep well in storage.
c. The test weight per bushel is lowered.
d. The germination is lowered.

Some of the problems caused by delaying combining until the grain reaches 14 per cent moisture are as follows:

a. More shattering takes place. (About one bushel per acre each five days.)
b. More cutter bar loss.
c. More weed and legume growth takes place causing more green material to be taken into the combine.
d. More risk of lodged grain.
e. Test weight per bushel will be reduced. (Figure 57) (One pound per bushel each four days.)

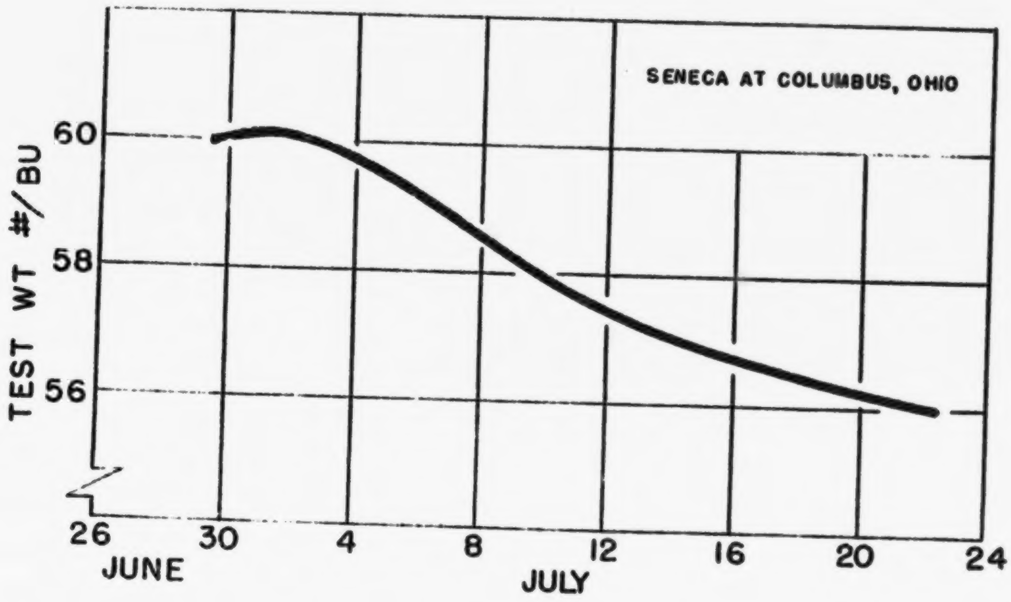


Figure 57. Test weight per bushel decreases as the harvest date is delayed.

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[1] Johnson, W. H., "Harvesting and Drying of High Moisture Wheat," OAES Bulletin 841, 1959.

The principal reason for the reduction in test weight per bushel for grain standing in the field is that as the grain dries and is rewetted with rain or dew it swells and does not re-dry back to its original volume. Thus there are less kernels in a bushel and the weight is lower.

Recent tests conducted over a period of five years at the Ohio Agriculture Experiment Station show that grain losses can be reduced by starting to combine when the grain reaches 20% moisture. (Fig. 58) At this moisture level the test weight is kept high, germination is not harmed, and the kernels are not damaged if the machine is properly adjusted.

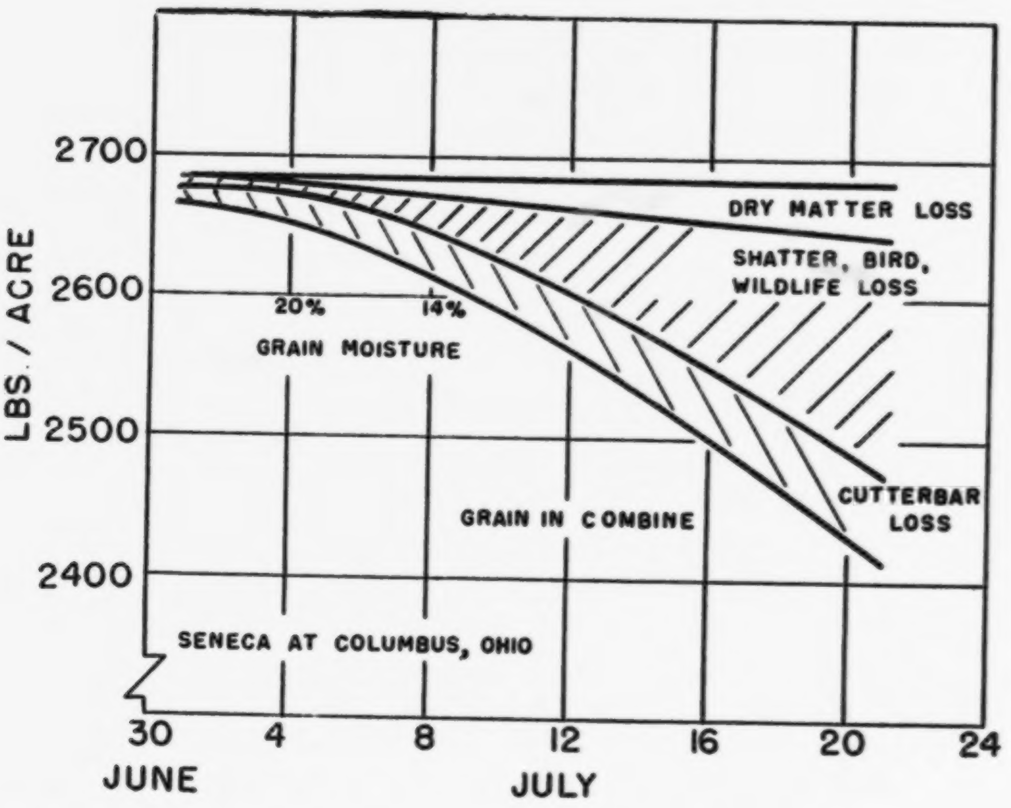

Figure 58. Grain losses increase as harvesting time is delayed.

If high moisture grain is harvested it must be dried to 14 per cent moisture before it can be safely stored. The cost of drying, either on the farm or at the elevator, must be compared with the advantages of early harvesting.

Under good harvesting conditions it will take about 5 days for wheat to dry in the field from 20 per cent moisture to 14 per cent. (Figure 59) Under poor conditions it has required up to 16 days. Thus, at least 5 or more days can be gained by starting to combine when the grain reaches 20 per cent moisture.

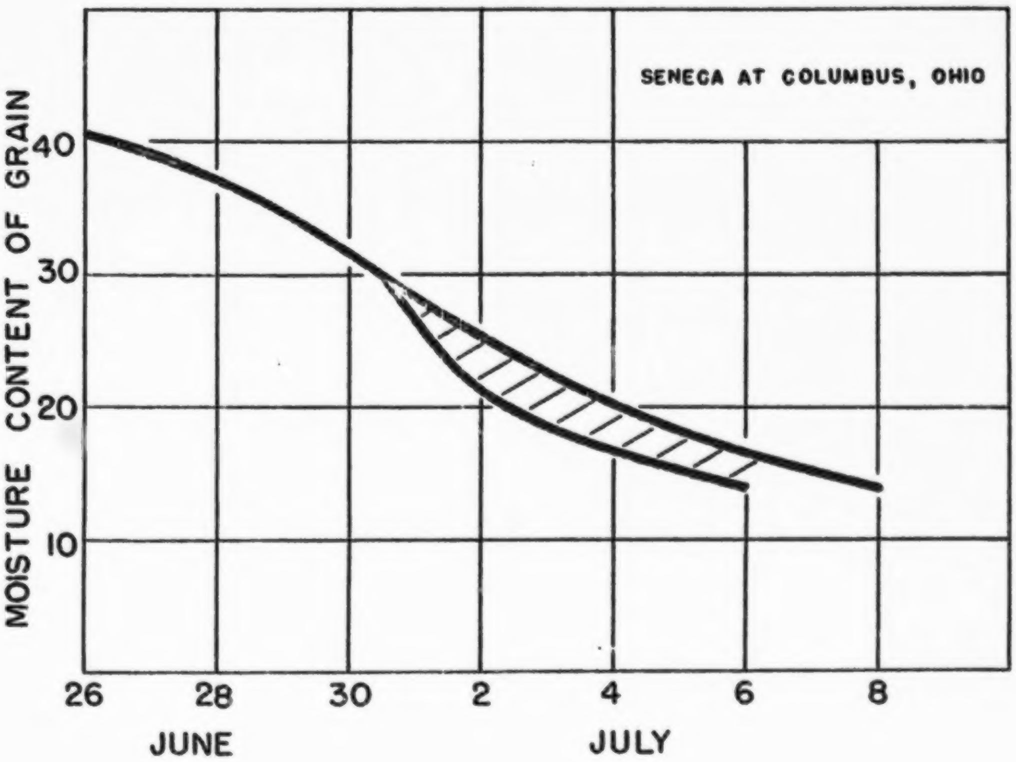

Figure 59

Rate of drying wheat standing in the field.

Tests show that combining high moisture wheat (14 to 20 per cent) has the following effects on losses in the different areas of the combine:

(1) Cutter bar loss is less. The loss in 20 per cent grain is about 1/2 that in 14 per cent grain.
(2) Cylinder loss increases slightly but can be held to less than one per cent with proper cylinder-concave adjustment.
(3) Rack loss is lower. There is less over-threshing.
(4) Shoe loss is lower. There is less over loading since more chaff clings to the straw.

The total loss is less when high moisture wheat is combined. Refer back to Figures 57 and 58.

The following recommendations are given by the Ohio Experiment Station for combining high moisture grain. "At 20 per cent grain moisture the cylinder concave clearance on rasp and bar type cylinders will have to be adjusted at a near minimum, 3/16" to 1/4", for the high moisture harvest, and then be increased as the grain becomes drier. A good rule of thumb is to check for unthreshed grain and adjust the cylinder-concave clearances or cylinder speed until about six grains per square foot are found in the head."

Problem: Farmer Jones started combining his wheat at 20 per cent moisture and completed the job before it reached 14 per cent moisture. His combining losses were 3 bushels per acre, and the test weight per bushel was 59 pounds. His cost of drying the harvested grain was 5¢ per bushel.

Farmer Brown started combining his wheat when it reached the 14 per cent moisture level. His losses were 5 bushels per acre, and the test weight per bushel was 56 pounds. He had no cost of drying.

The actual yield for each farmer was 45 bushels per acre before harvesting losses, and the discount for test weight per bushel is 1¢ for each 1/2 pound under 60 pounds.

If the price of wheat is $1.80 per bushel, what is the gross (total) income per acre for each farmer?

Student exercise: If you raise wheat at home would you recommend the practice of starting to combine when the grain moisture content reaches 20 per cent?

Keeping your home situation in mind, make a list of advantages and disadvantages of the practice. On some of these items you will need to find the extra cost that would be involved and on others the extra returns you might expect if the practice were followed. If you want to do more studying ask your teacher for a copy of the Experiment Station Bulletin 841, "Harvesting and Drying of High Moisture Wheat."

2. Soybean harvesting recommendations: [1] Losses with the combine have commonly been from 10 to 20 per cent of the available crop. Recent research at the Ohio Agricultural Experiment Station shows that with proper adjustment and operation of the combine and timely operation up to 95 per cent of the crop can be harvested.

Source of Loss: The first step in adjusting the combine is to determine the source of loss and its cause as outlined in section III of this manual.

Harvesting Tips: The following harvesting tips have been given by the Experiment Station researchers: High moisture combining of soybeans is considered to be when the kernels are above 12 per cent moisture, and the pods are dampened from dew or rain. (Notice that some of these recommendations are different from those given for wheat.)

a. Adjust the cylinder and concave so that cylinder losses will be practically nothing. In soybeans this will not have a tendency to overload the rack and shoe with chaff as it would in wheat. When high moisture beans are being harvested the cylinder will need to be run at nearly twice the speed recommended for dry beans. Cylinder clearance generally need not be changed. At high cylinder speeds germination will be reduced, but this will not reduce the market quality of the crop.

b. Lower the cutterbar to about four inches above the ground if possible. This adjustment reduces shatter loss due to direct cutting of beans and stubble loss caused by cutting above the pods. The distribution of pods above the ground is affected to some extent by variety, but the greatest difference is caused by the method of planting. The general tendency is that the thicker the plant population the higher the pods will be set on the plant. Thus, if the plant spacing within the row remains nearly constant and the width between the rows is narrowed, the pods should set higher on the plants.

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1. Lamp, B. J., Johnson, W. H., Harkness, K. A., Smith, P. E., "Soybean Harvesting," OAES Bulletin 899, 1962.

c. Adjust the reel so that:

(1) The bat speed is about 25% faster than ground speed. (Fig. 60)

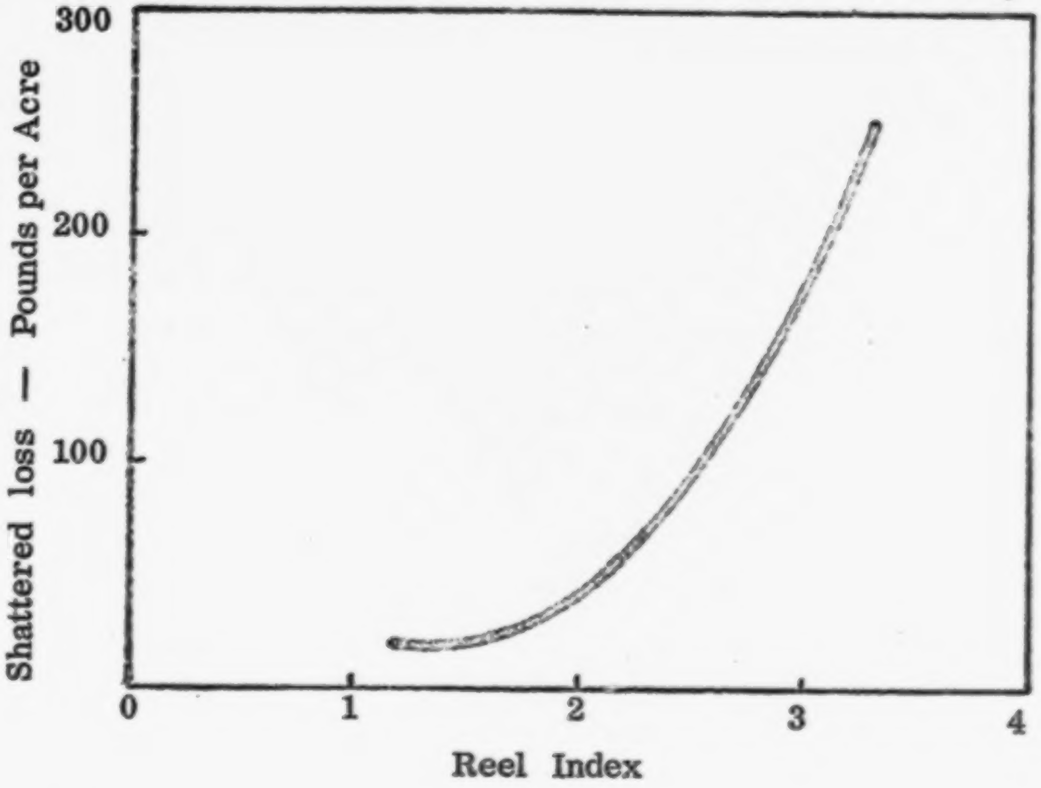


Figure 60

The faster the reel operates in relation to the ground speed the greater the shattered loss will be. Combine speed 2.6 to 2.9 m.p.h. Bean moisture 10 - 11 %. (1 = reel traveling at ground speed of combine, 2 = reel traveling twice combine ground speed, etc.

(2) The bat penetrates the grain no more than necessary to hold the beans while being cut and move them onto the platform. (Figure 61) In case of lodged beans the reel will need to be operated at a lower setting.

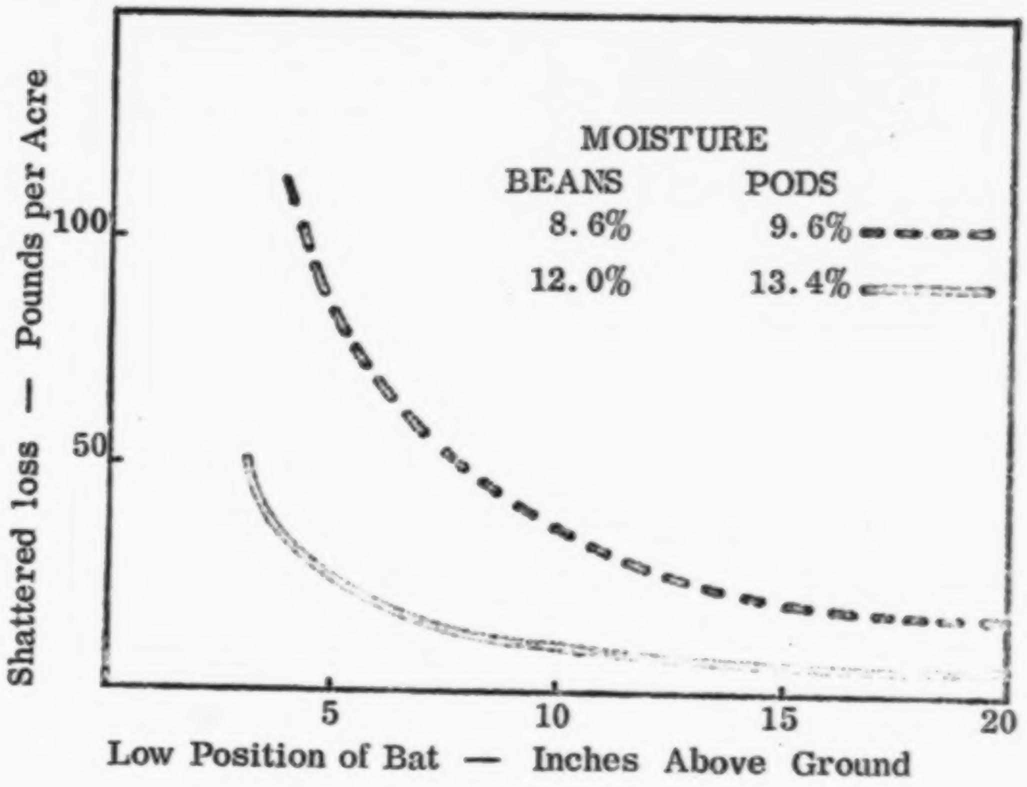


Figure 61

Shatter losses increase as the reel is adjusted downward. Dry beans shatter more than moist beans.

(3) The axis of the reel is adjusted so that it is 6 to 12 inches ahead of the knife. Except for stalk carryover this adjustment has little effect upon losses.

d. Keep forward speed reasonable. The effect of speed on losses is shown in Figure 62. The increase in loss is due largely to stripping of beans at the cutterbar.

e. Don't wait until the beans are overdry. Beans are harder to thresh at higher moisture (13 - 16 per cent), but they are also harder to shatter at the reel and the cutterbar. Beans above 14-15 per cent moisture will need to be dried artificially. Another loss will show up when beans are too dry. Market price is based on 13 per cent moisture and beans with less moisture will be penalized since it will require more beans to make a bushel.

f. Take advantage of the dew. Harvesting losses can be reduced by early morning harvesting. (Figure 63) This same advantage can be gained by combining after dry beans have been re-wet following a rain. When wet beans are combined the cylinder speed must be increased.

A farmer needs to know how many favorable working days he can expect to have available for a given operation. This will help him in determining the number of acres of a crop that he can take care of and the size of machinery he needs to do the required jobs.

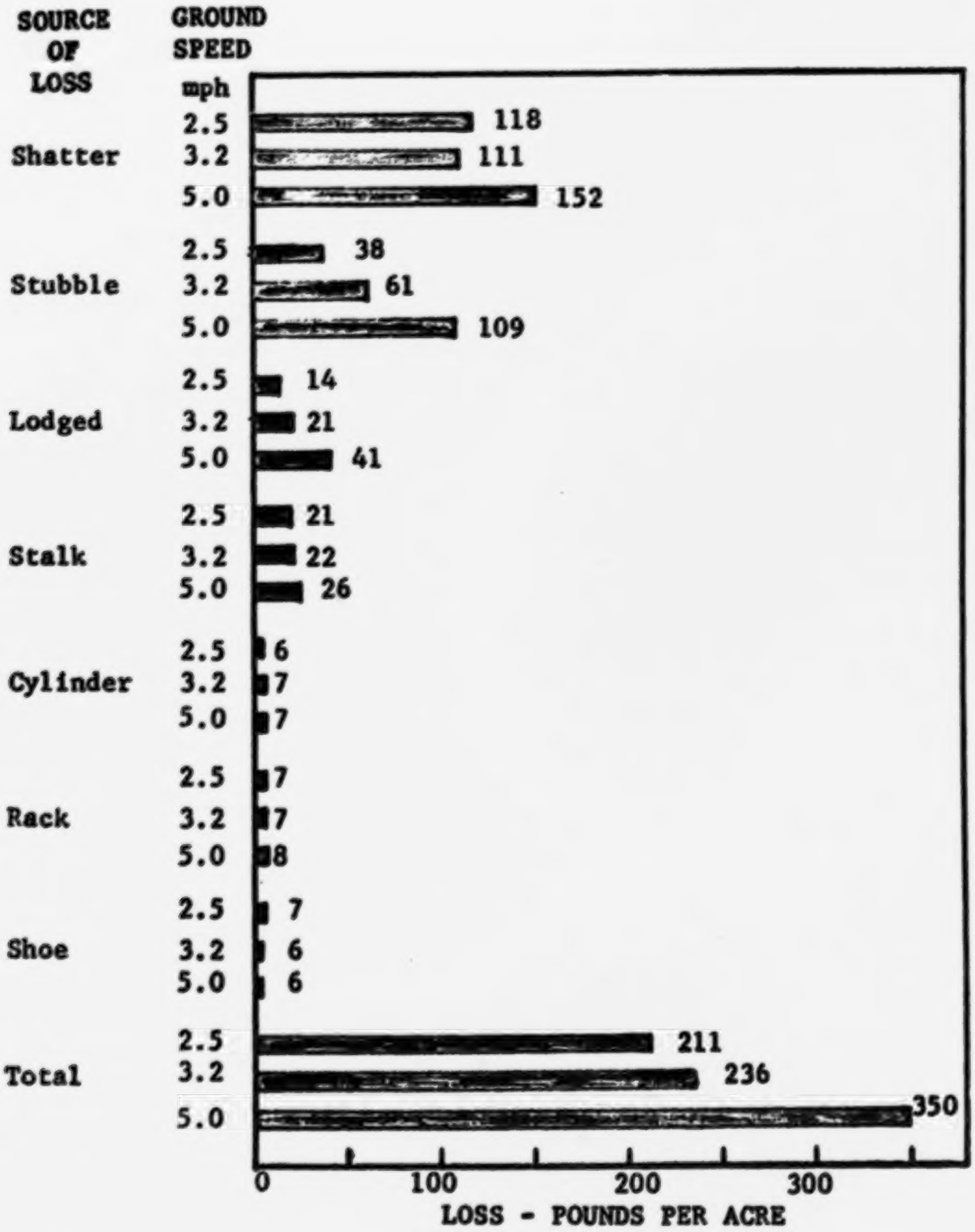
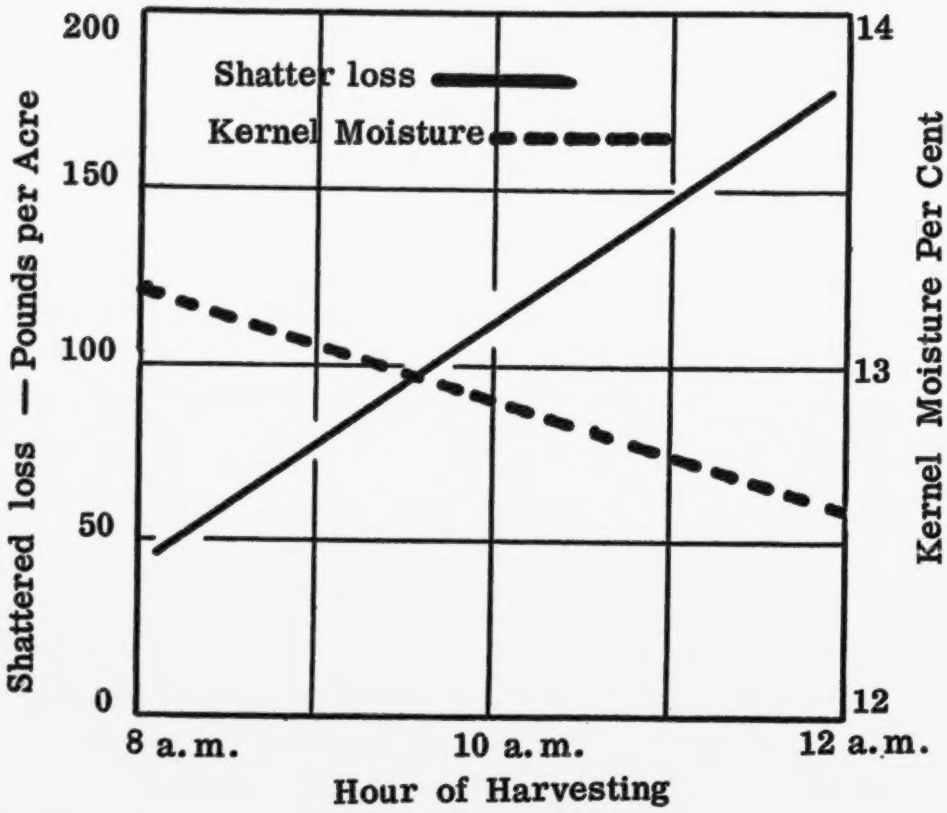


Figure 62. The effect of combine ground speed on harvesting loss.

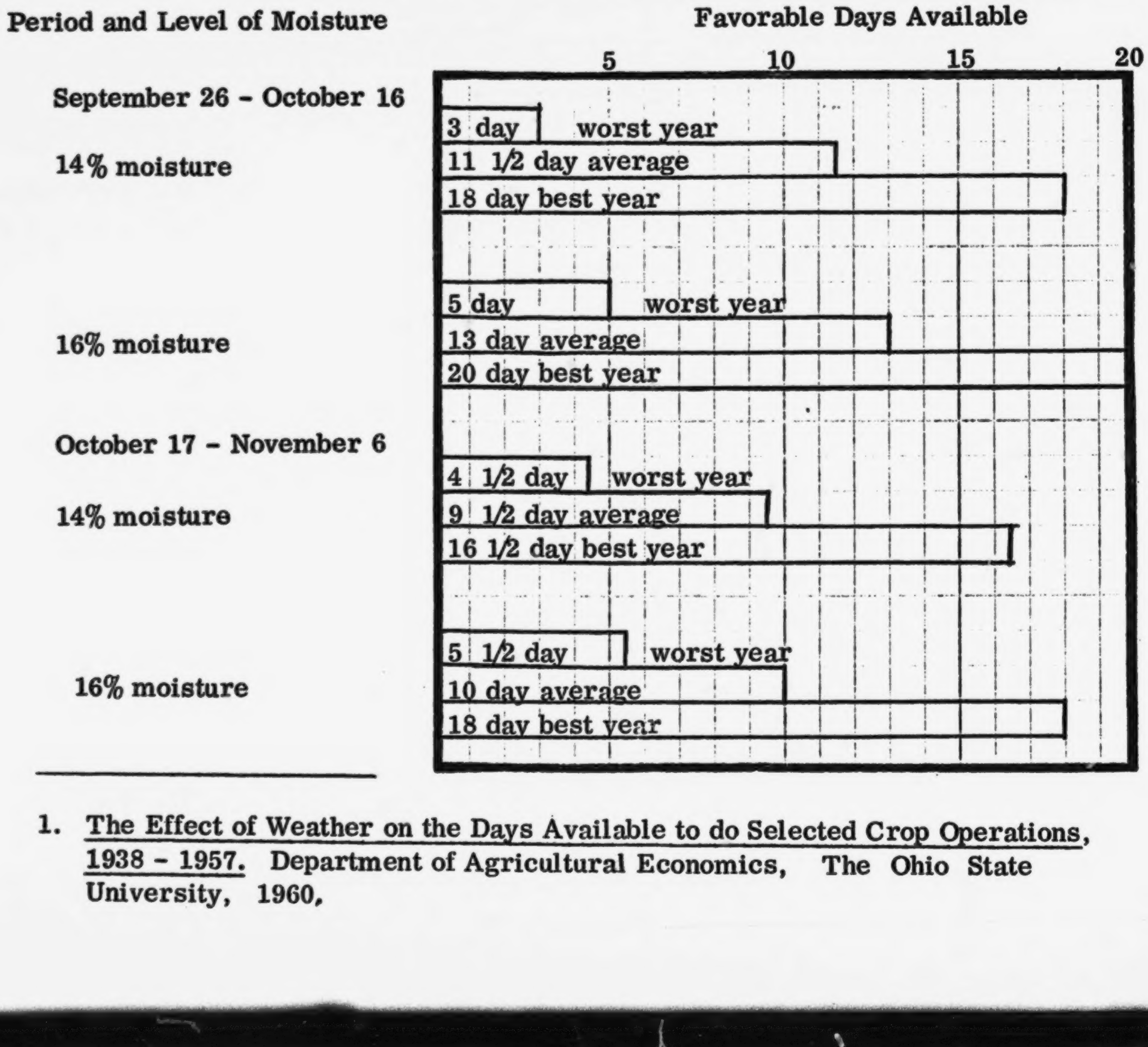
Figure 63

The effect of the time of day upon shattered loss and kernel moisture. As the beans dry during the day the shatter loss increases.



The Department of Agricultural Economics at The Ohio State University[1] has conducted a study to determine the information. The days available for both early and late harvest of soybeans for two moisture levels are given in Figure 64.

Figure 64. Favorable Days Available for Combining Soybeans. (1938-1957)



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1. The Effect of Weather on the Days Available to do Selected Crop Operations, 1938 - 1957. Department of Agricultural Economics, The Ohio State University, 1960.

3. Corn harvesting recommendations.[1] The combine can be converted from small grain to shelled corn harvesting by exchanging the small grain cutting and feeding unit for the corn head attachment.

The corn head snaps the ears from the stalks and feeds them into the cylinder for shelling. (Figures 65 and 66)

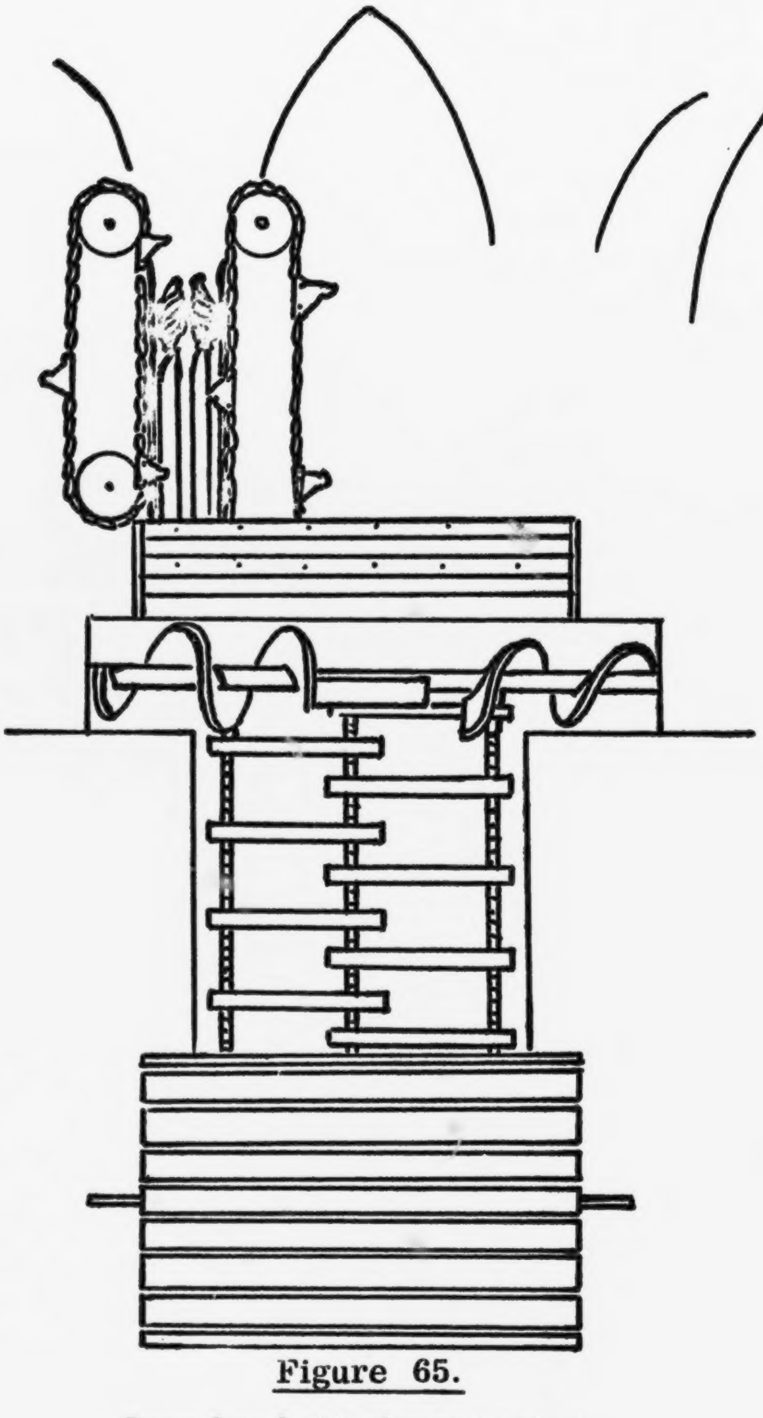

Figure 65.

Corn head attachment using a conveyor to feed material into the cylinder.

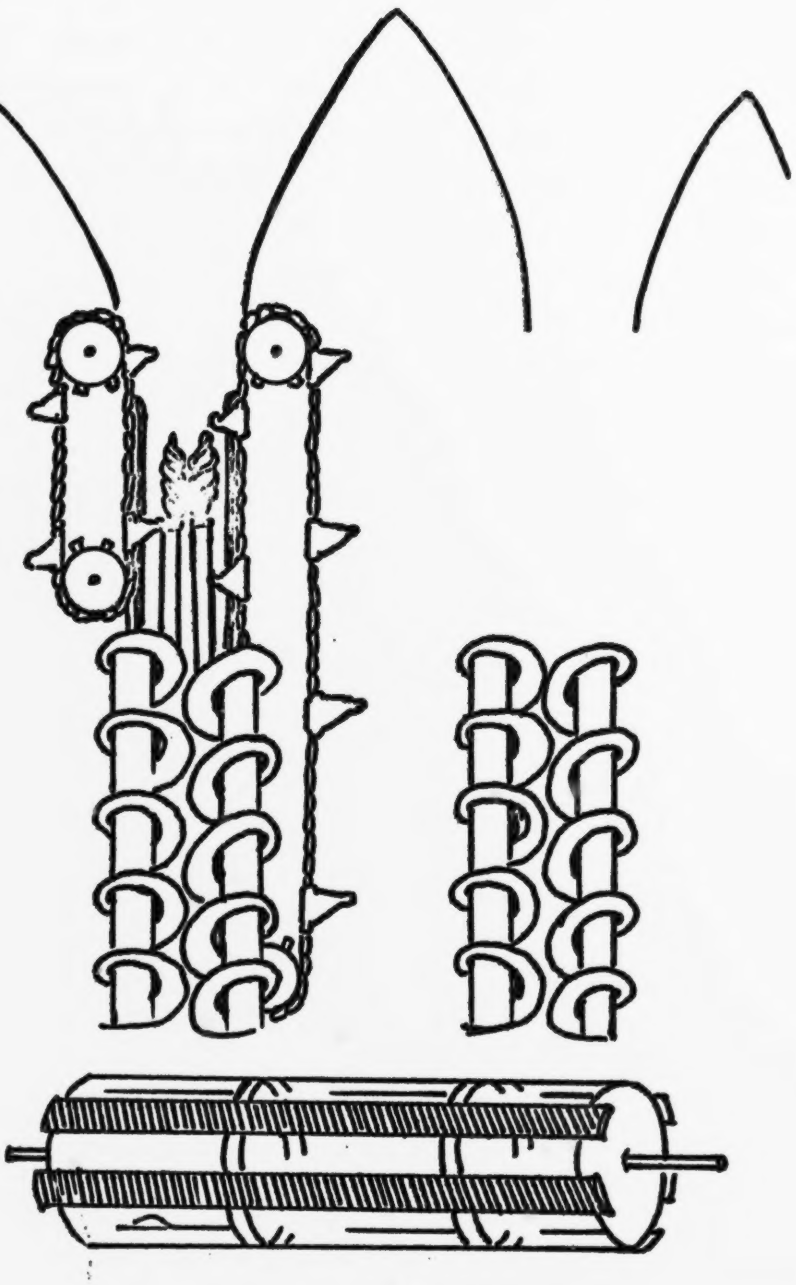

Figure 66.

Corn head attachment using augers to feed material into the cylinder.

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[1] Johnson, W. H., Lamp, B. J., Henry, J. E., and Hall, G. E., Corn Harvesting Performance at Various Dates, ASEA Paper 61-603, 1961

The corn head operates somewhat differently than the corn picker. The stalks of corn are pulled straight down through the stalk rolls. Snapping bars or stripper plates snap the ears off at the shank. (Figure 67)

Since the ears do not come in contact with the rolls, as in the picker, there is much less shelling in this area. A field study by agricultural engineers in 1964 revealed that average losses for machines with snapping bars was one bushel per acre as compared to the conventional snapping roll which lost an average of three bushels per acre.[1]

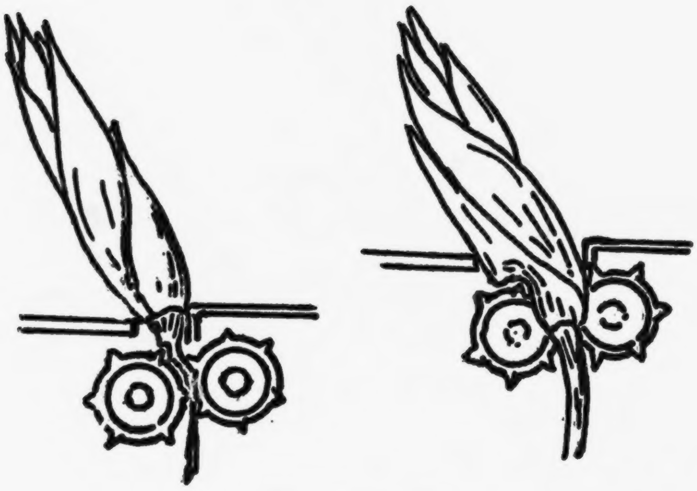

Figure 67

Snapping bars should be adjusted as close together as possible and still allow passage of stalks.

From the snapping area the ears are then fed into the cylinder for shelling. (Figure 68) See your operator's manual for recommended attachments to convert the cylinder and concave to the job of shelling corn.

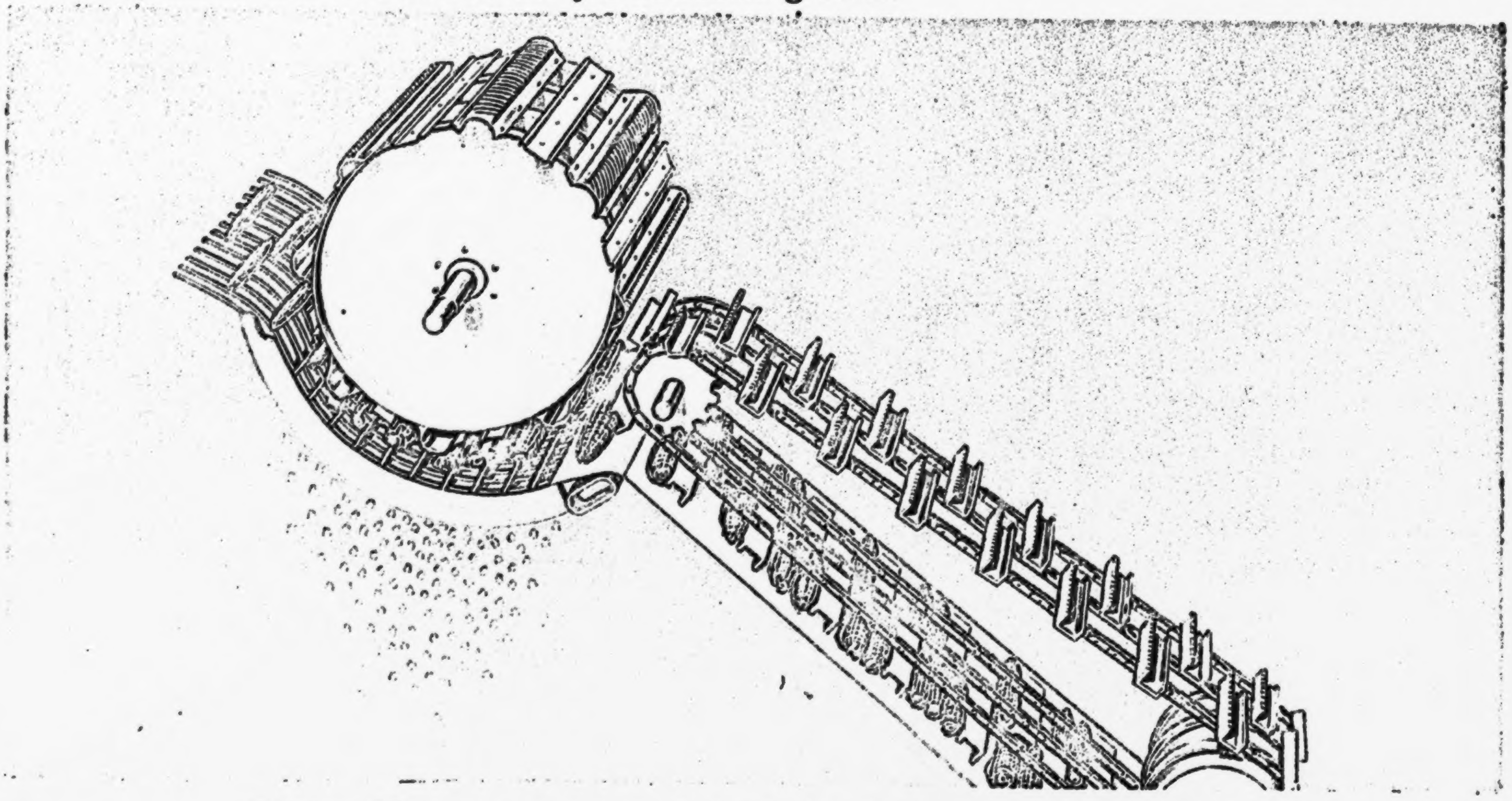

Figure 68. The ears are fed into the threshing unit where they are shelled by the rubbing action of the rotating cylinder against the concave. (Courtesy of International Harvestor Company.)

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1. Byg, D. M., Gill, W. E., and Johnson, W. H., "Machine Losses in Harvesting Ear and Shelled Corn," Bulletin MM-247, The Ohio State University, 1965, p. 3.

(1) Pre-harvest loss. (The amount of corn lost before harvesting starts.) The longer corn dries in the field the greater the pre-harvest losses will be. Figure 69 shows that pre-harvest losses increase as corn dries down in the field.

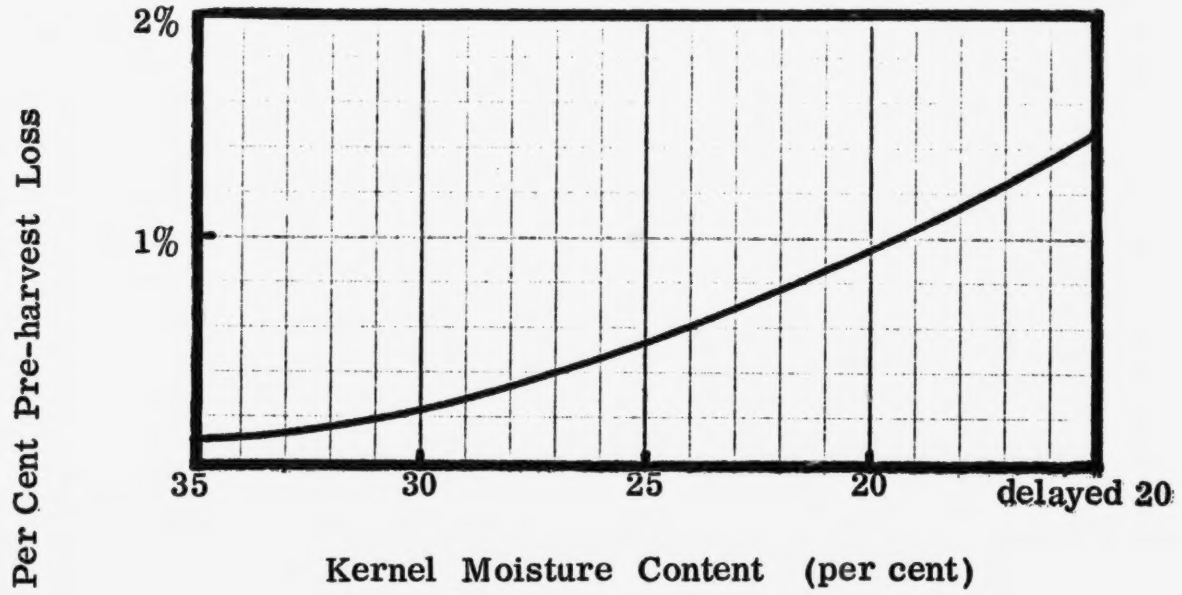
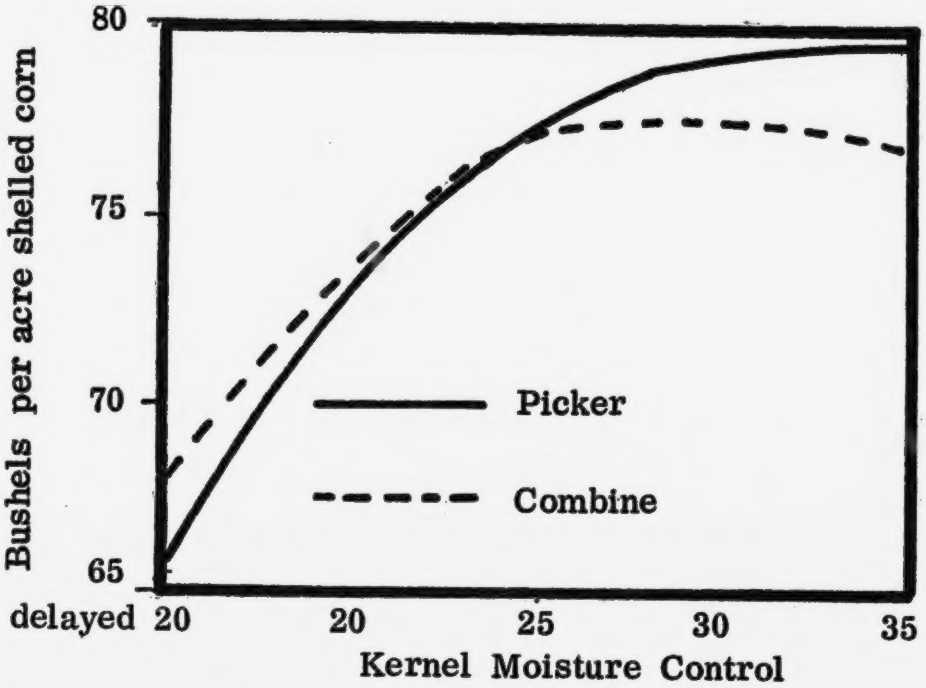


Figure 69. Pre-harvest corn losses increase as corn dries down before harvesting. (W. H. Johnson, "Corn Harvesting Data," OAES, 1964.)

(2) Highest machine yields (the amount of shelled corn actually harvested by the combine or picker) are obtained when corn is combined between 20 and 30 per cent moisture. (Figure 70)

Figure 70

Yields of dry shelled corn per acre when harvested at different moisture levels with a combine and a picker. (Based on an average yield of 80 bushels per acre.)



At high moisture content (35 per cent) a part of the reason for combine yields being lower than picker yields is due to invisible losses. (Losses caused by imperfect shelling such as kernel tips remaining in the cob and small chips of kernels which could not be measured as a visible loss.) The effect of moisture content of kernels on the invisible loss in yield is shown in Figure 71.

A 1964 field survey by agricultural engineers revealed that the amount of fine materials (corn chips and meal) found in the grain tank was in the range of .4 to 3.7 per cent of the total yield and averaged 1.5 per cent.[1]

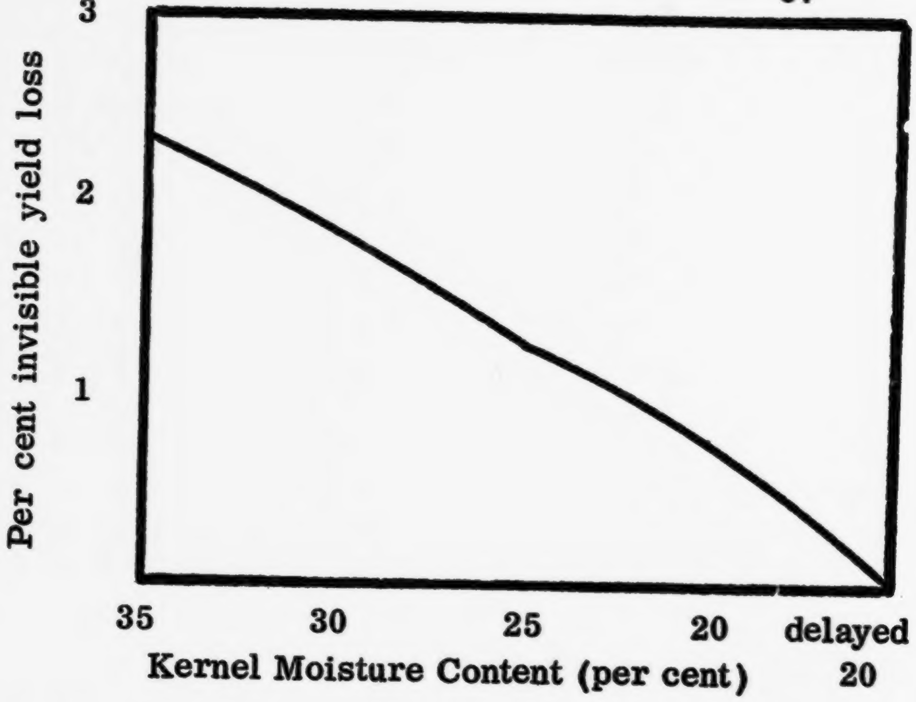


Figure 71 The invisible loss in combining corn decreases as the corn dries down. (W. H. Johnson, "Corn Harvesting Data" OAES, 1964,)

Corn will not mature and dry down at exactly the same dates each year although the moisture content will be approximately the same for a given time each year. Research conducted by the U.S. Department of Agriculture[2] provides us with information that makes it possible to estimate, as early as the water blister stage, when kernels will dry to 30 per cent moisture.

There is no exact guage to use in measuring rate of drying:

(a) Drying rate decreases as moisture in the corn goes down.

(b) Drying rate changes fairly consistently within a certain moisture range, but weather (cool and damp or hot and dry) may greatly influence rate of change in early stages of drying and again when the grain is below the 25 per cent.

The estimated rate of drying is illustrated in figure 72.

(3) Ears dropped. The amount of lodging (a stalk broken over below the ear or leaning greater than 45 degrees) will greatly influence the number of ears lost. (Figure 73)

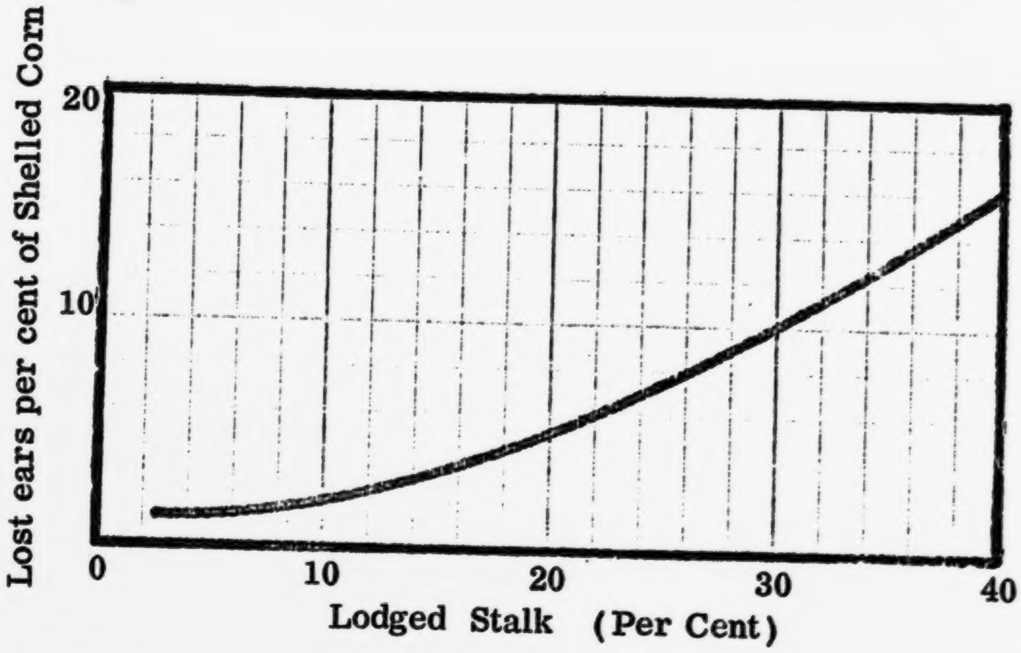


Figure 73. Influence of lodged stalks on lost ears of 15,000 plants per acre.

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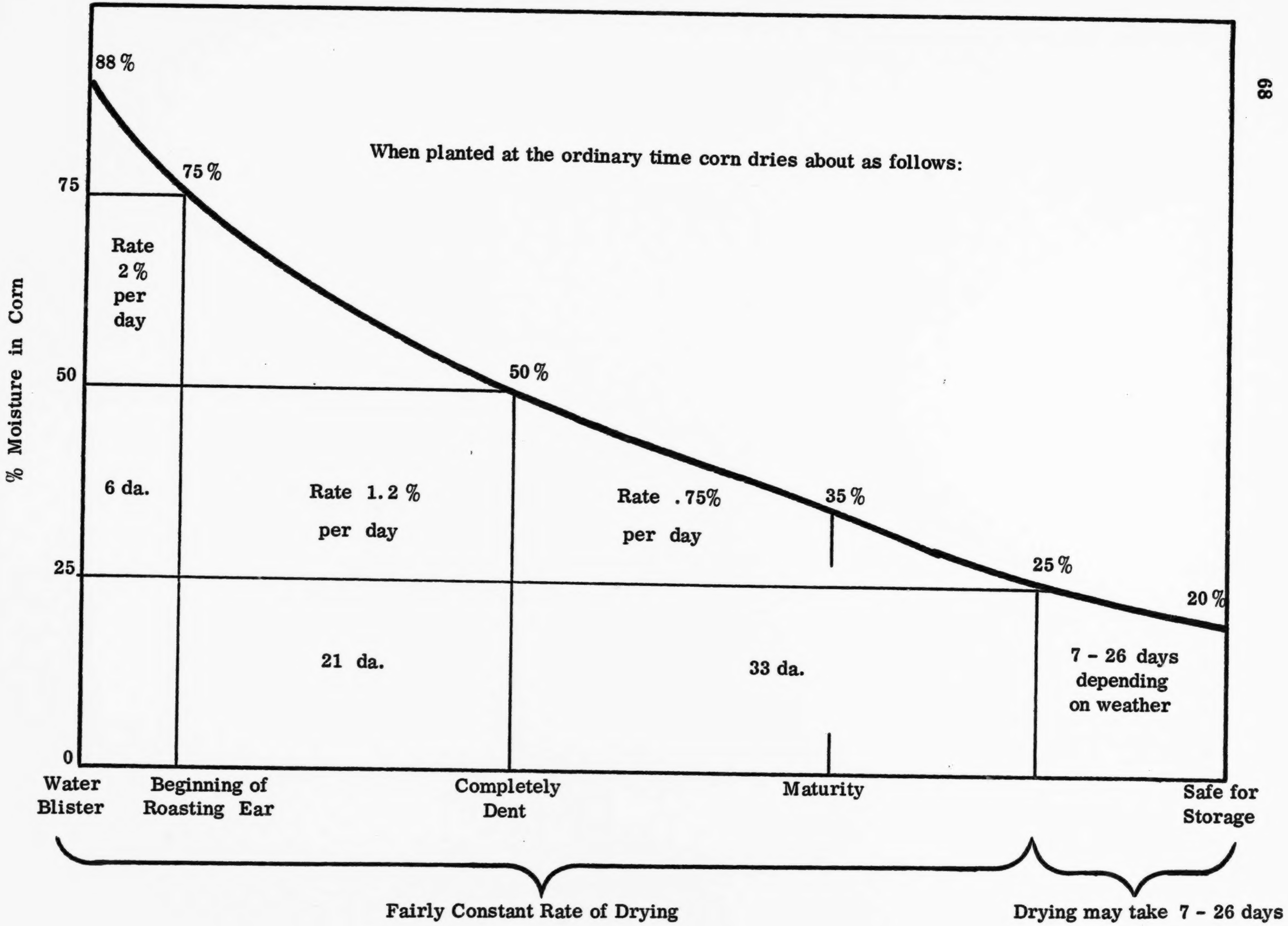
1. Byg and others, ibid., p. 7.

2. How to Tell When Corn Will Mature, Agricultural Research, U.S.D.A., September, 1955.

Figure 72. How to Tell When Corn Will Mature. (USDA Agr. Research Sept. 1955)



Ear losses from corn combines averaged 3.15 bushels per acre as compared to the corn picker which averaged 1.73 bushels per acre loss. Due to the danger of running stones through the combine many operators are afraid to lower the gathering mechanism enough to pick up broken stalks. The stripping bars, commonly found on combines gathering units, also require more careful driving than the picker snapping rolls to keep losses down.[1]

As corn weathers in the field, some ears drop before harvesting, but the machine is responsible for most of the ears dropped. A light blow by the gathering unit will knock off a mature ear before it is gathered in. Figures 74 and 75 show that date of harvest as well as moisture content influence the amount of lodging. Delayed field drying led to a higher ear loss caused by a greater amount of lodging.

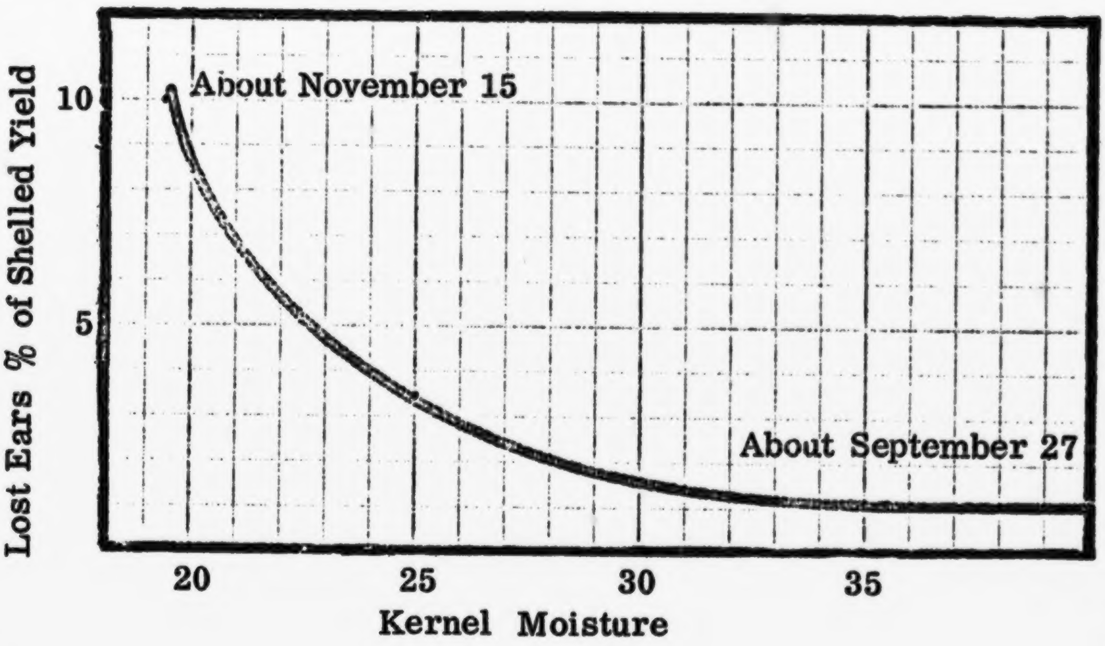


Figure 74

Late season harvesting results in increased loss of ears. (Wooster)

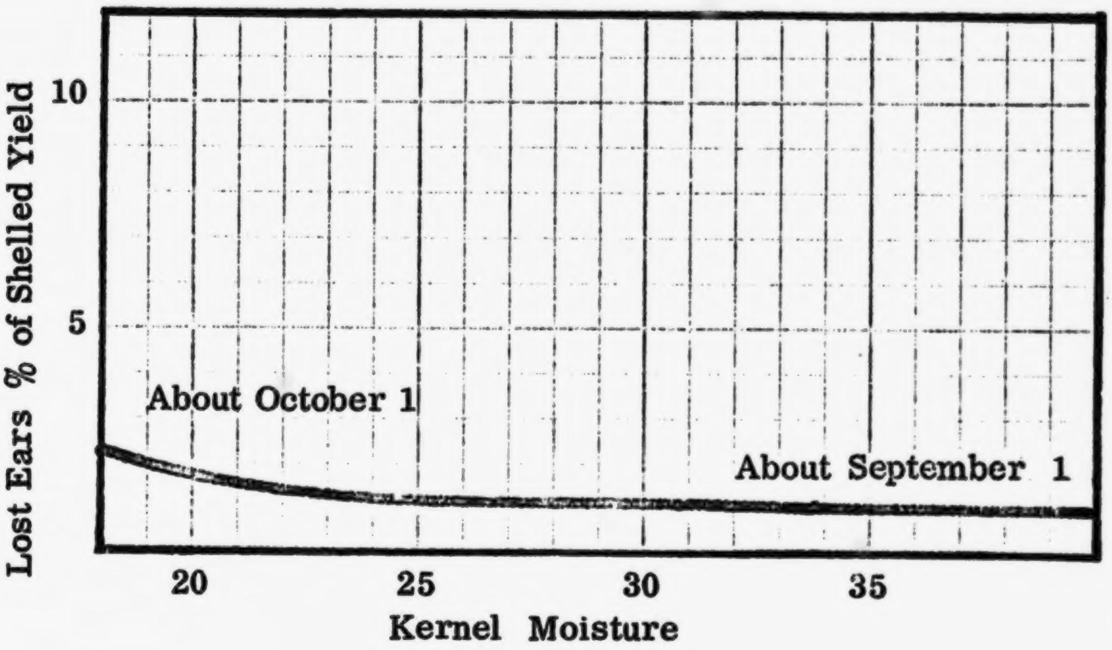


Figure 75

Early season harvesting resulted in less loss of ears. (Columbus)

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[1] Byg and others, ibid., p. 3.

(4) Cylinder loss. The cylinder loss increases as the amount of kernel moisture increases. (Figure 76) This loss can be recognized by the kernels left on the cob. It is possible through proper adjustment to keep the cylinder loss under one per cent.

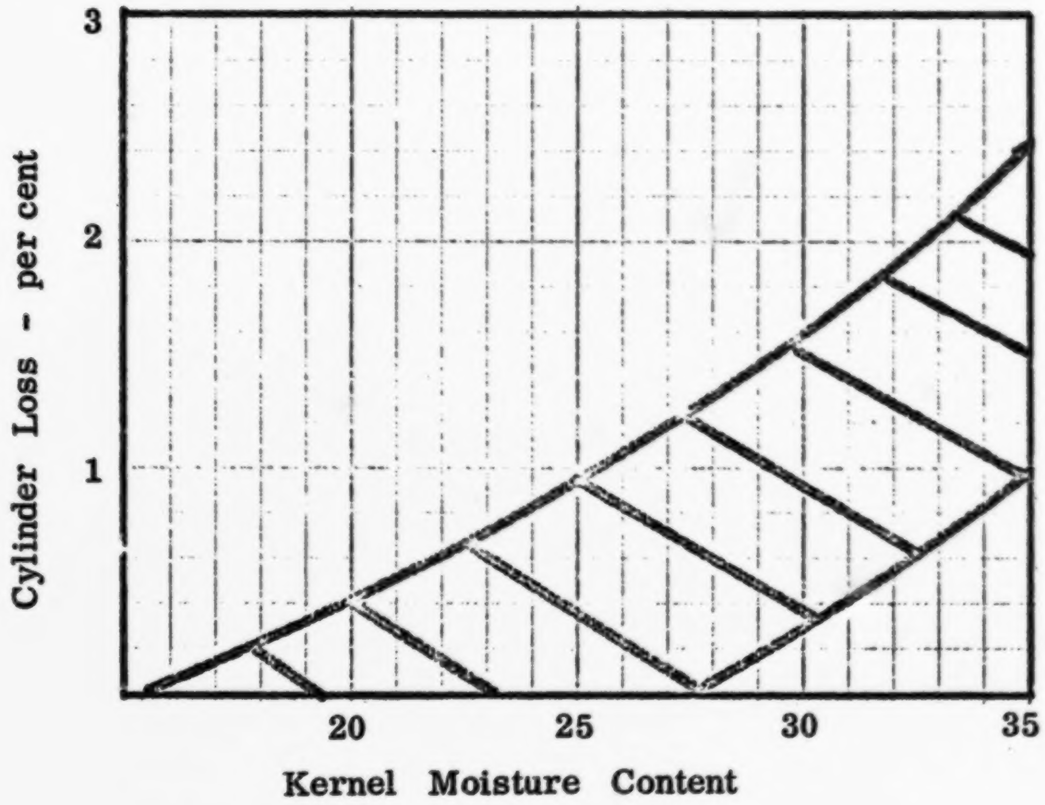


Figure 76

Range of cylinder loss at different kernel moisture levels.

(5) Separation loss. The separation loss increases as the amount of kernel moisture increases. (Figure 77) This loss can be recognized by the amount of loose kernels passing through the machine.

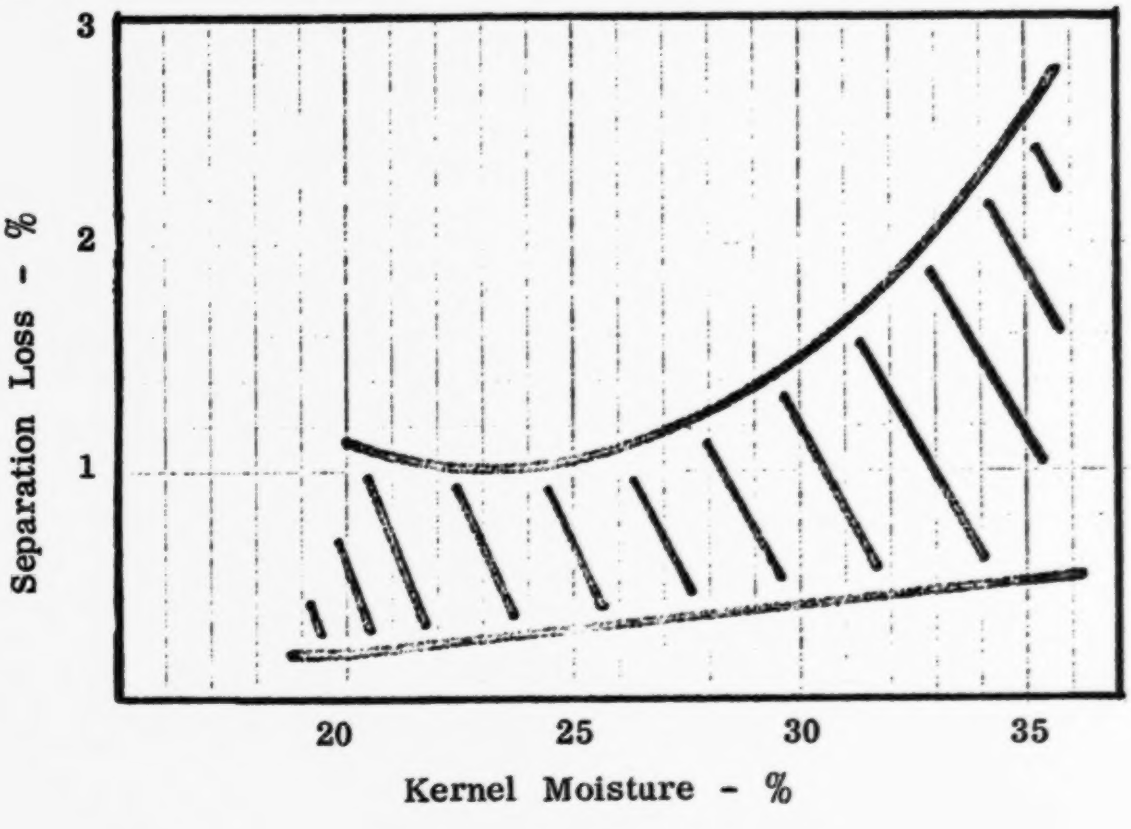


Figure 77

Range of separation loss at different kernel moisture levels. (William Johnson, OAES, 1964)

(6) Test Weight Per Bushel. The market price of corn may be affected by the test weight per bushel. Tests show that generally high moisture corn tests lighter than dry corn due to moisture and kernel damage. (Figure 78) See Figure 3, page 3, to determine approximate market discounts for corn.

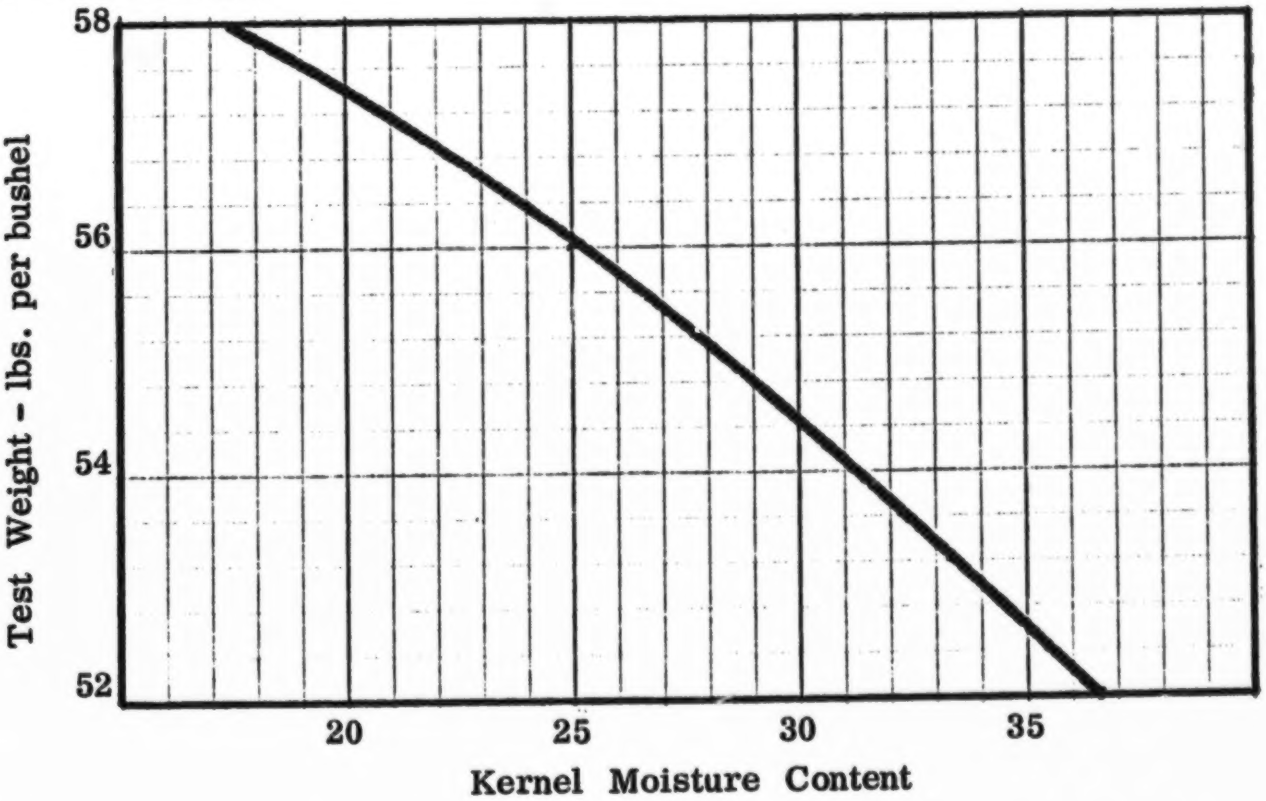
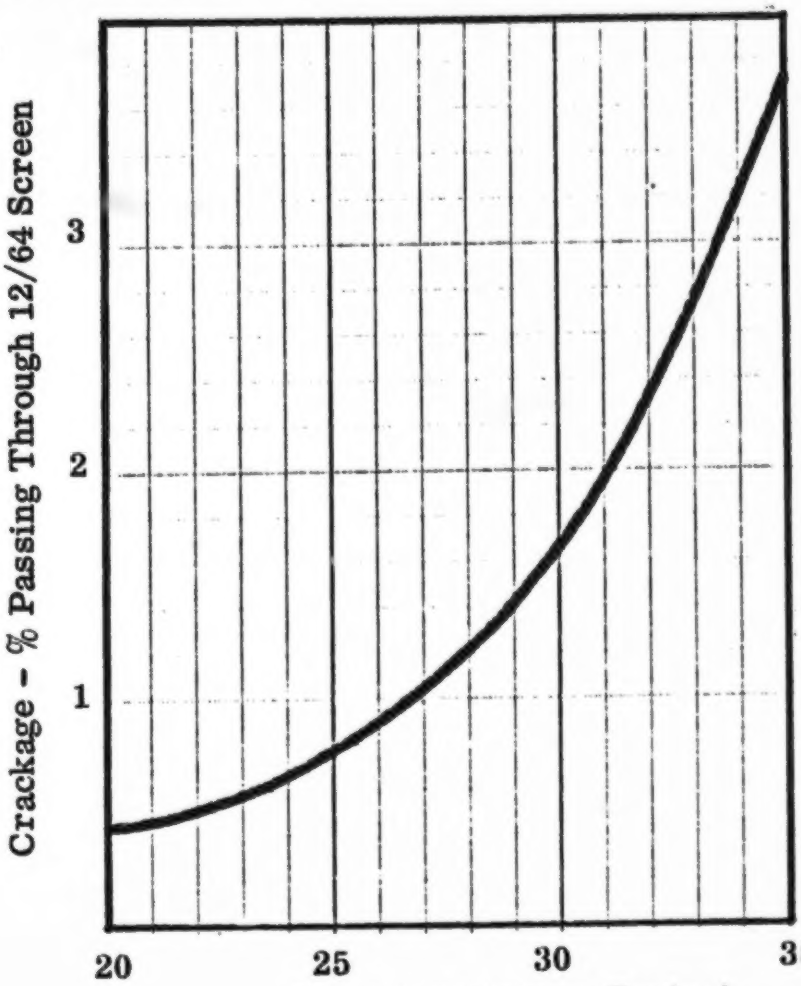


Figure 78. High moisture corn has a lower test weight per bushel. (Test weight observed after corn from field has been dried to 15 1/2 per cent moisture.)

(7) Cracked kernels.
Tests show that kernel damage will be increased when high moisture corn is combined. (Figure 79) For the effect of kernel damage on market price of corn see Figure 3, page 3.) Kernels with cracks in the seed coating will not keep in storage as well as sound kernels. Weevils are more of a problem and air for drying will not flow freely through damaged kernels.

Figure 79. Kernel damage increases when corn is combined at high moisture content.



Student Exercise: Farmers are faced with the management decision of whether to use the combine in harvesting their corn or to use another method. Using the information presented here and other reliable sources decide whether or not you should use the combine in harvesting your corn crop.

Some of the factors to consider are as follows:

(1) Use to be made of the crop:
  Marketed from field.
  Stored and marketed at later date.
  Kind of storage and drying facilities available.
  Corn to be fed to livestock.

(2) Number of acres to be harvested.

(3) Harvesting machinery available.

(4) Comparison of combine harvesting losses with losses from other methods.

Table 10 and Figure 80 will assist you in comparing the losses under different moisture levels and expected length of harvest period for the picker and the combine. For example, if you pick corn at 27.5% moisture traveling at 2 miles per hour and require 21 days to complete the job, the expected loss would be 6.7% of the total yield. Under the same conditions of time and moisture the expected combine loss would be 7.3% of the total yield. If, in the same example, picking was delayed until the corn reached 20.8% moisture, the loss would be 13.8% of the total yield.

You can also compare losses at 2 m.p.h. and 5 m.p.h.

(5) The effect of different harvesting methods on market and storage quality of corn.

What is your management decision, and why did you decide on this method of harvesting your corn?

Table 10. Average total field losses of corn as a percentage of gross corn yield, by length of the harvest period and moisture content at the beginning of harvest

Length of harvest, days	Moisture at beginning of harvest, %						
	35.0	33.0	30.2	27.5	25.1	22.9	20.8
	Average field losses, % of gross corn yield						
	Picker at 2 mi. per hour						
9	3.2	3.2	3.9	5.2	7.1	9.4	11.8
13	3.3	3.4	4.0	5.7	7.7	10.0	12.4
17	3.4	3.6	4.6	6.2	8.3	10.6	13.1
21	3.5	3.8	5.0	6.7	8.9	11.2	13.8
25	3.8	4.1	5.4	7.3	9.4	11.9	14.5
29	4.1	4.5	5.9	7.8	10.0	12.5	15.3
	Picker at 5 mi. per hour						
9	4.8	4.7	5.6	7.6	10.3	13.5	16.9
13	4.9	4.9	6.1	8.3	11.1	14.4	17.8
17	5.0	5.2	6.6	9.0	11.9	15.2	18.6
21	5.2	5.6	7.2	9.7	12.8	16.1	19.6
25	5.6	6.1	7.9	10.5	13.6	16.9	20.5
29	6.0	6.6	8.6	11.3	14.4	17.9	21.5
	Combine at 2 mi. per hour						
9	6.5	6.2	6.1	6.4	7.4	9.2	11.3
13	6.4	6.2	6.2	6.7	7.9	9.7	11.8
17	6.3	6.2	6.3	7.0	8.3	10.3	12.3
21	6.3	6.2	6.4	7.3	8.8	10.8	12.9
25	6.3	6.3	6.7	7.7	9.3	11.3	13.4
29	6.3	6.4	7.0	8.2	9.8	11.8	14.0
	Combine at 5 mi. per hour						
9	8.3	8.0	7.9	8.5	10.1	12.7	15.5
13	8.2	8.0	8.0	8.9	10.8	13.4	16.1
17	8.1	8.0	8.2	9.4	11.5	14.1	16.8
21	8.1	8.0	8.5	10.0	12.2	14.8	17.6
25	8.1	8.2	8.9	10.5	12.8	15.5	18.3
29	8.3	8.4	9.4	11.2	13.5	16.2	19.1

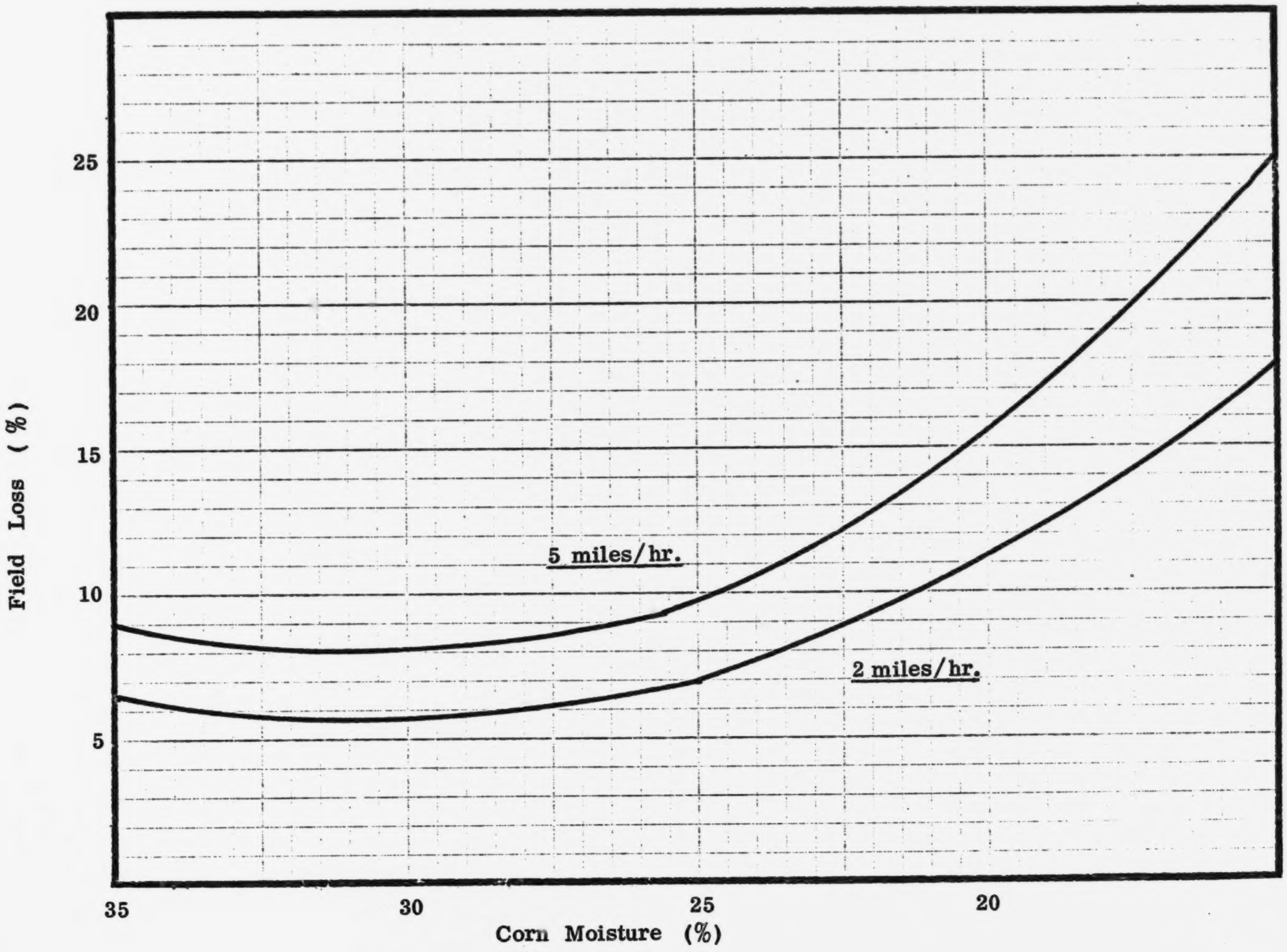
Prepared by William H. Johnson, Department of Agricultural Engineering, The Ohio Agricultural Experiment Station.

Table 10. Average total field losses of corn as a percentage of gross corn yield, by length of the harvest period and moisture content at the beginning of harvest

Length of harvest, days	Moisture at beginning of harvest, %						
	35.0	33.0	30.2	27.5	25.1	22.9	20.8
	Average field losses, % of gross corn yield						
	Picker at 2 mi. per hour						
9	3.2	3.2	3.9	5.2	7.1	9.4	11.8
13	3.3	3.4	4.0	5.7	7.7	10.0	12.4
17	3.4	3.6	4.6	6.2	8.3	10.6	13.1
21	3.5	3.8	5.0	6.7	8.9	11.2	13.8
25	3.8	4.1	5.4	7.3	9.4	11.9	14.5
29	4.1	4.5	5.9	7.8	10.0	12.5	15.3
	Picker at 5 mi. per hour						
9	4.8	4.7	5.6	7.6	10.3	13.5	16.9
13	4.9	4.9	6.1	8.3	11.1	14.4	17.8
17	5.0	5.2	6.6	9.0	11.9	15.2	18.6
21	5.2	5.6	7.2	9.7	12.8	16.1	19.6
25	5.6	6.1	7.9	10.5	13.6	16.9	20.5
29	6.0	6.6	8.6	11.3	14.4	17.9	21.5
	Combine at 2 mi. per hour						
9	6.5	6.2	6.1	6.4	7.4	9.2	11.3
13	6.4	6.2	6.2	6.7	7.9	9.7	11.8
17	6.3	6.2	6.3	7.0	8.3	10.3	12.3
21	6.3	6.2	6.4	7.3	8.8	10.8	12.9
25	6.3	6.3	6.7	7.7	9.3	11.3	13.4
29	6.3	6.4	7.0	8.2	9.8	11.8	14.0
	Combine at 5 mi. per hour						
9	8.3	8.0	7.9	8.5	10.1	12.7	15.5
13	8.2	8.0	8.0	8.9	10.8	13.4	16.1
17	8.1	8.0	8.2	9.4	11.5	14.1	16.8
21	8.1	8.0	8.5	10.0	12.2	14.8	17.6
25	8.1	8.2	8.9	10.5	12.8	15.5	18.3
29	8.3	8.4	9.4	11.2	13.5	16.2	19.1

Prepared by William H. Johnson, Department of Agricultural Engineering, The Ohio Agricultural Experiment Station.

Figure 80 Relation of Moisture and Date of Harvest to Average Field Loss of Corn With Combine Under Ohio Conditions.



Ohio Agricultural Experiment Station

Byg, D. M., Gill, W. E., Extension Agricultural Engineers, The Ohio State University.

Corn Harvesting OPERATIONAL AIDS Cause Condition	Not Driving in Center of Rows	Ground Travel Too Fast, *Too Slow	Front End of Corn Head Too High	Snouts Not Free to Float	Snapping Rolls Too Loose, *Too Tight	Stripper Plates Too Wide, *Too Close	Gathering Chains Too Wide at Front	Gathering Chains Too Loose	Stripper Plates Too Close at Front	Stalks Too Green -- Moisture High	Gathering Chains Too Close at Rear	Broken Snapping Roll Tension Spring	Snapping Rolls Worn	Foreign Matter in Roll Tension Spring	Snapping Rollsclips Worn or Missing	Plugging Over Rolls	Cylinder Speed Too High, *Too Low	Engine Speed Too High, *Too Low	Rack Speed Too High	Excessive Tailings Return	Walkers Plugged	Chaffer Sieve Opening, Too much,*Too little	Improper Air Direction	Air Amount Too Much, *Too little	Concave Clearance, Too great,*Too little	Tailing Gate Too High, *Too low	Bottom Sieve Open Too Far
Leaving Ears in Field	x	x x*	x	x	x		x																				
Stalks Not Entering Stripper Plates	x	x				x*	x	x																			
Plugging over Snapping Rolls		x			x	x*				x	x	x	x	x	x												
Shelling at Snapping Rolls		x	x		x	x										x											
Losing Corn Over Rack		x								x							x	x	x	x	x						
Losing Corn Over Shoe		x																x x*				x*	x	x x*		x*	
Sieves Plugging																	x					x	x	x*	x*		
Corn Kernels Still on Cob		x								x							x*								x		
Excessive Cracking										x							x			x					x*	x	
Unclean Grain in Tank										x												x	x	x*	x*		x

Figure 81. Corn Harvesting Condition Operational Aids.

IV. ECONOMICS OF OWNING A COMBINE.

References for additional study: "Crop Economics for Ohio," Bulletin 423 and "Farm Custom Rates," Leaflet 74, Agricultural Extension Service, The Ohio State University.

If you are a grain farmer you will be faced with the following problem: Should I own my combine or hire a custom operator to harvest my grain? In solving this problem you will need to keep two things in mind.

1. How many acres of all grain crops will I be harvesting? The more acres you harvest the lower your cost per acre will be when you own your combine.

2. How long would I need to wait for a custom operator? Harvesting losses increase rapidly after the best date for combining has passed.

A. What are the costs of combining?

It is easy to determine the charge per acre for custom combining. If you do not know the usual rate for your area call some local custom operator for their prices or refer to the Farm Custom Rates bulletin.

It is much more difficult to determine the cost per acre for combining when you own your own machine. Your costs of combining can be divided into the following three areas:

1. The overhead or fixed cost of owning the machine. These are costs you have whether you use your machine or not. They are as follows:

    a. Depreciation
    b. Interest on the invested capital
    c. Taxes
    d. Insurance

2. The variable or operating costs. These costs largely depend on the amount of use given the machine during the year. They include the following items:

    a. Fuel
    b. Lubrication
    c. Repairs
    d. Operator's labor

3. Risk-loss from delayed harvesting. This cost will only appear when you must wait for the custom operator to do your combining. (Refer to section III of this publication.)

B. Determining the cost of owning and operating a combine.

The following example will help you in figuring how much it will cost you to own and operate a combine on your farm.

Example: A farmer has 40 acres of soybeans, 40 acres of oats, and 20 acres of wheat to harvest each year. He has been using a custom operator to harvest these crops and has found that on the average he has to wait about five days beyond the best time to combine for the custom operator to do his work. He has priced a twelve foot, 70 horsepower gasoline engine driven self-propelled combine and found that the model he needs costs $7,000. Should he continue using a custom operator or should he buy the new machine? How can he determine which decision to make?

Procedure for estimating the cost of owning the combine:

Step 1. Determining the overhead costs.

a. Annual depreciation:

$$\frac{\text{Purchase price } \$7,000}{\text{Expected life} \ldots 10 \text{ years}} = \text{annual depreciation } \underline{\$700.00}$$

b. Annual interest:

$$\frac{\text{Interest rate}}{\text{8\% short term}} \times \text{Purchase Price } \frac{\$7,000}{2} = \text{Annual interest on capital invested } \underline{\$280.00}$$

c. Annual personal property tax: (This is an average figure. Check the local rates when figuring your situation.)

Purchase Price $7,000 x 30% = $2,100.00 Assessed value.

Assessed Value $2,100.00 x 3% = Annual Property Tax $63.00.

d. Annual Insurance:

$$\text{Purchase Price } \frac{\$7,000.00}{2} = \$3,500.00 \text{ Average Value}$$

$$\text{Average Value } \frac{\$3,500.00}{100} \times \$.40 \text{ (rate per \$100)} = \text{Annual Insurance } \underline{\$14.00}$$

Total Overhead Costs $1057.00

Step 2. Determining Variable Costs.

The actual variable costs cannot be accurately determined without records of these items of expense. However, few farmers would have these detailed records available. The figures used in this illustration to estimate costs have been taken from the University of Illinois farm management studies.

a. Fuel costs: Motors normally require about .07 gallons of gasoline or .05 gallons of diesel fuel per horsepower hour of operation. Hours of use can be estimated by using the following table from Ohio Bulletin 423, "Crop Economics in Ohio."

Time Used for Combining in West Central Ohio

Job Done	Size of Tractor Used[1]	Man Hours Used per acre[2]	
		Average	Range for Middle Half of Farms
Combine with 5-foot combine	2, 3	.95	.97-1.27
Combine with 6-foot combine	2, 3	.85	.72-1.05
Combine with 7-foot combine	2, 3	.75	.65- .95
Combine with 10-foot combine	SP[3]	.46	.38- .59
Combine with 12-foot combine	SP	.42	.36- .50

R. H. Blosser, "Crop Economics for Ohio," The Ohio State University.

1. Stated in number of plows tractor is rated to pull.
2. Unless otherwise stated, number of tractor and machine hours used per acre is same as number of man hours used.
3. Self-propelled.

Maximum drawbar horsepower 70 x .07 gasoline or .05 diesel x price of fuel $.20 x 42 hours* = fuel cost $41.16

*100A x .42 hr. per A = 42 hrs. use.

b. Lubrication Costs: Oil costs about 10 per cent of the total fuel cost and grease about 3 per cent of the total fuel cost making a total of 13 per cent of fuel costs for lubrication charges.

fuel cost $41.16 x 13% = lubrication cost $5.35

c. Repair Costs: Repair costs are caused by deterioration, rust, accidental breakage, and wear. They do not depend entirely on the amount of use given a machine and usually increase as the machine ages. An average charge per year is 4 per cent of the purchase price of the combine.

purchase price $7,000 x 4% = annual repair charge $280.00

d. Operator's Labor:

hours per acre .42 x 100 acres x $1.50 per hr. = labor costs $63.00

Total Variable Costs $389.51

Step 3. Determining Total Cost Per Year:

Overhead Costs	$ 1057.00
Variable Costs	$ 389.51
Annual Cost of Owning Combine	$ 1446.51

Step 4. Determining Average Cost Per Acre for Combining:

$$\frac{\text{Annual Cost of Owning Machine} \quad \$1446.51}{\text{Number Acres Harvested} \quad 100 \text{ acres}} = \$14.46 \text{ Cost Per Acre}$$

This is the actual cost per acre based on the situation used in this example and will change as any of the factors in the example change. The figures for the factors in your situation will be different from those used here.

Step 5. Comparing Cost of Owning a Combine With the Custom Rate:

My cost per acre when I own my combine is $____________
The custom rate per acre in my community is $____________

The extra cost of custom combining due to crop loss caused by delay beyond the best harvest date is not figured here. You may obtain information that will help you in estimating your probable losses due to delayed harvesting be referring to Section III of this publication.

Some additional factors to consider before deciding to buy a combine or hire a custom operator are as follows:

a. Timeliness of operation. What will be the loss in yield and quality if the time of the crop is delayed?
b. Does the custom worker have the ability to do a satisfactory job of combining?
c. Do I have the mechanical ability to operate a combine efficiently?
d. How does owning a combine fit into my overall farm plan? (Labor supply, crops raised, long time farm plan.)
e. Can I reduce my cost by joint ownership?
f. Will a used machine meet my needs?
g. Is it possible to lease a combine when I need one?
h. Is adequate repair service available in my community?
i. Will the combine become obsolete before I have it paid for or worn out?
j. Could I use the money I would invest in the combine to a better advantage elsewhere in my business ? (Opportunity cost.)
k. If I purchase the combine do I have the financial ability to pay for it? (Debt load, repayment ability, capital resources.)
l. Would I have time to do custom work?

Step 6. Determining the Number of Acres of Annual Use of a Combine to Justify Owning a Machine:

The more acres combined per year, your own as well as custom work, the lower the overhead cost per acre will be. The following formula will help you in determining the number of acres of annual use required to cover the overhead cost of owning the machine:

$$\frac{\text{Annual Overhead Cost } \$\,1,057.00}{\text{Custom Rate } \$500 - \text{Variable Cost/A } \$3.89} = \begin{array}{c}\text{Number of acres}\\ \text{combining required}\\ \text{to break even}\end{array} \quad 952\text{ A}$$

As the difference between custom rates and variable costs per acre becomes smaller more acres must be harvested to make the overhead cost per acre comparable to custom rates.

Farm management studies show that high overhead costs result in low profits on many farms. The procedures explained in the example above can serve as a guide in determining the overhead costs involved in owning a given combine for harvesting your crops. For a more detailed study of the effect of overhead costs on profits see Part V, Analysis of the Farm Business, page 55, of the publication, "Farm Records - A Management Tool," available from the Ohio Vocational Agriculture Instructional Materials Service.

The cost per acre of combining is shown graphically for a 7 foot pull-type and a 12 foot self-propelled combine in Figure 82. A study of this chart will give you a rough estimate of whether or not you can afford to own a combine. Figure 82 was adapted from "Crop Costs and Returns," B 909, Ohio Agricultural Experiment Station, 1962.

Figure 82. Combining costs decline as acreages increase.